ARCHITECTURAL CONCRETE

VOLUME THREE NUMBER ONE

HERSHEY SPORTS ARENA

Hershey, Pa.

Designed and built by Hershey Lumber Products

D. Paul Witmer, Manager

Z-D Roof designed by Roberts and Schaefer Co.

Chicago, Ill.

The largest single span concrete roof in America shelters hockey, skating and other indoor sports at Hershey, Pa. (see cover). Completely concrete, including floor, walls, roof and bleacher structure, the big Sports Arena is one of the chocolate capital's many fine community buildings. Hershey Lumber Products, with D. Paul Witmer, manager, designed the building. The Z-D roof was designed by Roberts and Schaefer Company of Chicago, Anton Tedesko supervising the construction.

Published by PORTLAND CEMENT ASSOCIATION • 33 West Grand Avenue, Chicago

Architectural
CONCRETE

Sports Palace for Chocolate Town

By D. Paul Witmer*

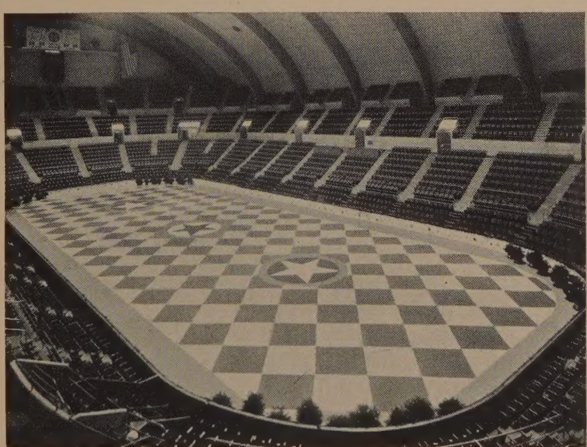
ON last December 19 the largest single span concrete roof in America resounded (with perfect acoustics) to the cheers of a capacity house of rabid hockey fans in Hershey, Pa. The occasion was the inauguration of the Hershey Sports Arena, mammoth new athletic plant designed and built for the pleasure of the citizens of this tiny community that looks like a college campus, but is famous for its model government, fine buildings and chocolate.

The new arena is one of several community institutions built by the Hershey interests for the purpose of welding their 2,200 citizen employes into a big happy family. The town itself is built on choice farm lands in the rolling hill country of Pennsylvania. Its major industry is chocolate, although building the town and supplying it with community houses, churches, schools, hotels and halls has become a rather large industry in itself. The Hershey plan—to erect some new, important structure each year—envisions many splendid things for the future. It will keep the town's construction forces busy for many a year.

Hershey Sports Arena replaces an old landmark convention hall adorned with four cupolas, turned into an Ice Palace in 1921 when hockey came to Hershey, but made obsolete in 1935-36 when a few thousand more fans clamored to watch the games than could be accommodated. Construction of other buildings was under consideration at the time, but the Sports Arena seemed of greatest current need. So, when the hockey season was rung down last spring, ground was broken and work started.

It was an unusual project from the very moment of its inception. Excavation started and foundations were placed before plans were anywhere near complete. This was possible because Hershey Lumber Products, the designers, were also the builders. Even though bad weather forced cessation of work for a month and a half after ground was broken March 11, 1936, the building was opened on December 19—17 days after the last forms were stripped and approximately 8 months after construction started. During this record time a 356x245-ft. structure, 100 ft. high, was built, topped by the largest Z-D roof on the continent, and finished and equipped by 18 different trades—all working practically simultaneously.

Thorough investigation of available concrete aggregates was made before concrete construction started. As a result of tests, washed river sand and local crushed limestone were selected. Wood falsework was used for the roof and the lumber purchased was of sizes and lengths most commonly employed in everyday construction; hence, the salvage value was nearly 100 per cent for later use.



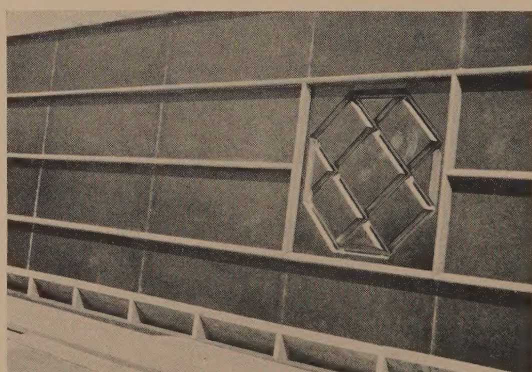
Colored ice makes a brilliant floor for carnival skating.

*Mgr., Hershey Lumber Products.

Hershey Sports Arena is 356 ft. long with window openings confined to one end. Large interior fixtures provide light.

The concrete plant presented a problem requiring careful study. Consideration was given to the use of concrete pumping equipment as well as to large-capacity mixers. But the question always came up—what would be done with this equipment after the job was finished? There would always be a barn foundation or floor, a new driveway, or normal size buildings such as plant additions to build—but only one Sports Arena in a lifetime. A number of two-bag mixers were available, so what turned out to be a most happy solution was finally decided upon. The two-bag mixers were used—two on each side of the structure. As it turned out, this scheme worked marvelously—so marvelously, in fact, that the original idea was always regarded as a sort of act of Providence. There were other happy thoughts, too.

The concrete for the main roof between expansion joints was placed in a continuous operation from the springing line at the walls up to the crown. At the beginning of a run of concrete the slope of the slab was very steep and concrete having a slump of about 1 in. was required. At this same elevation the arch rib is intricately reinforced and concrete with about a 6-in. slump was necessary for successful placing. It was simple to the point of the ridiculous—after it was learned—that one mixer on each side should mix 1-in. slump, the other 6-in. slump concrete. Different-colored tags were put on the buggies to tell which slump was which and everything proceeded smoothly. But, what a headache the mixer operator would have had jerking the water regulator up and down—wet mix, dry mix, wet mix—and about half the time the batches might have gone to the wrong place.



One of the large plaster molds for forming cast-in-place detail.

The entire structure was designed for 3000-lb. concrete. At the start a 1:2¼:2¾ mix was used; but later after experimenting in the field to eliminate sand streaks and honeycomb, a 1:2¾:2¼ mix was employed. Seven-day tests averaged around 2900 p.s.i. and 28-day tests about 4200 p.s.i.

Telephones were installed on each side from the concrete plant to the top of the hoist so that adjustments in the mix could be made rapidly as conditions demanded.

The walls up to the roof were cast against wood forms, some of the detail being formed with the wall. Other detail, panels of more intricate design, were precast in plaster molds in a shed at the building site.

Hershey Sports Arena comprises five separate sections longitudinally, each designed in such a way that as soon as the first roof section was completed and the scaffolding moved ahead for a second section, the carpenter force could follow with forms for the concrete bleachers. The bleachers are entirely separate from the building proper. When each section of bleachers was in place, steam fitters started installation of heating and plumbing and vacuum-cleaning systems. These, together with all other trades, created a parade from one end of the building to the other. Thus, when the last

section of roof was placed on November 17, the interior was at least 85 per cent completed.

Erection of the walls, due to the interrelation of the roof and rest of the structure, followed a rather unusual procedure. The wall was built in sections about 78 ft. long, including two arch hinges and a spandrel beam at the roof line cantilevered beyond each arch rib about 19½ ft. Concrete was placed in each rib up to approximately 4 ft. above the hinge and allowed to harden. Jacks were then placed between the footing and the hardened 4-ft. section of the rib to support and stabilize the load above.

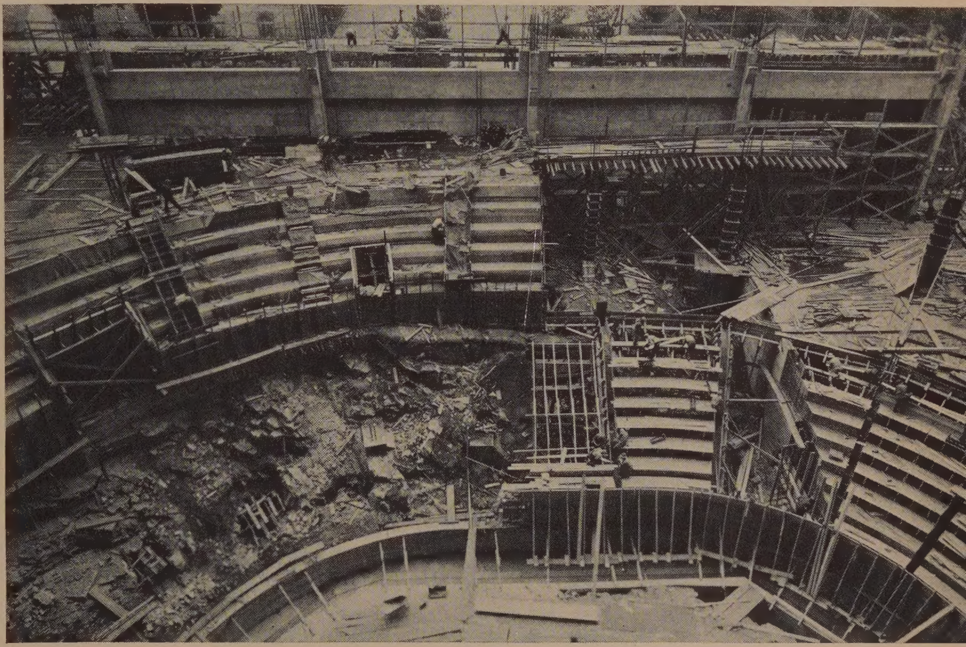
Concrete was then placed in the pilasters and arch ribs up to a construction joint at the roof level. At the same time the concrete was placed for the spandrel beam at that level and the slab and beams located at the level of an opening in the arches used as an entranceway to the bleachers. An accompanying illustration shows this construction.

After the flat roof, which extends along the sides of the building and covers the walkway leading to the bleachers, was placed, shoring was removed and curtain walls were cast between the pilasters. The coping of the parapet was precast in plaster molds and set in place after the wall was constructed. Other precast units were likewise inserted after the structural wall was completed.

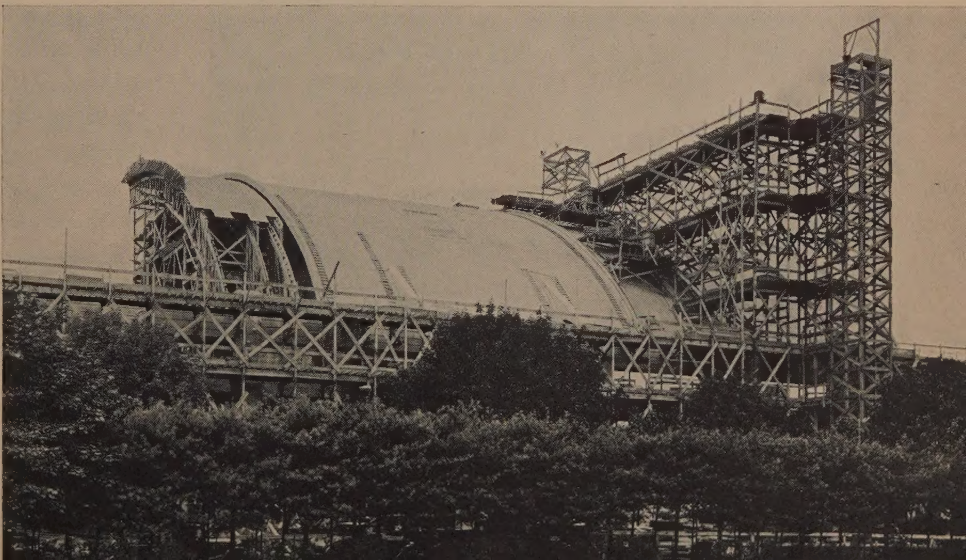
The design of the roof, of course, was the most unusual feature of the construction, and that is explained elsewhere. Certain construction methods were adopted in erecting the roof, however, that bear explanation here.

Centering for the roof was a huge scaffold erected inside the building. The

A unit of the roof consists of two arches with a 3½ in. thick concrete shell spanning 39 ft. between the arches and cantilevered 19½ ft. beyond each arch. Here is first section of roof in place.



While the roof was under construction, workers went ahead rapidly with erecting forms and placing concrete for the bleachers.



Half of the roof centering being moved into position for the next section of the barrel. At right is one of the runways with platforms at several levels facilitating concrete placing.

under form for the roof was lined with cork so prepared that it would bond with the lower side of the roof slab without mechanical aids and eventually become an acoustic lining for the ceiling.

On the lower 20 ft. of the roof a top form was used and was put in position after the concrete was placed. From that point to the crown, however, no top form was necessary; but finishers followed behind on scaffolds supported on the freshly placed concrete by wooden shoes or sleds. They hauled themselves up with rigging as work progressed.

The central portion of the roof was cast in three large sections 78 ft. wide over the 232-ft. span of the roof. Each of these sections included two arch ribs. Each end section was 54 ft. wide and included one arch rib and a portion of the end wall. The placing of the concrete in the arch ribs and the shell progressed symmetrically, beginning at the springings. The scaffolding bulged up slightly under the load of the concrete near the springings and finally settled an average of 3/8 in. To place the concrete for the first 78 ft. section required 54 hours. As the crew became more experienced, the placing time for the third section was reduced to 26 hours. The two end sections, which were somewhat smaller than the intermediate ones, required but 19 hours and 17½ hours, respectively.

When the concrete had attained the design strength and a modulus of elasticity of 3,000,000 p.s.i. as shown by cylinder and beam tests, the centering was lowered a few inches and the entire scaffolding moved forward to a location directly under the next section of roof to be placed. It was while this scaffolding was being inched along by men pulling it on concrete tracks set in the floor, that painters put a finishing coat of gray paint on the cork slab lining.

The bleacher structure, planned to seat 7,200 people, was under construction while the roof was being built. In fact, most of the bleachers were completed before the final section of roof was placed.

The heating system for this building is unique in that no attempt was made to heat the entire building to theater temperature. It is, however, most comfortable for hockey devotees who are warmed by steam lines under the seats, bringing heat to the occupant rather than distributing it over the entire area. In this manner a temperature of about 60 degrees is maintained—comfortable and economical.

Ventilation is achieved by 10 large exhaust fans located in the roof. Fresh air is brought in through various openings throughout the building and taken out by means of the fans which clear the building of smoke. It is possible for the fans to effect a complete change of air every 15 minutes.

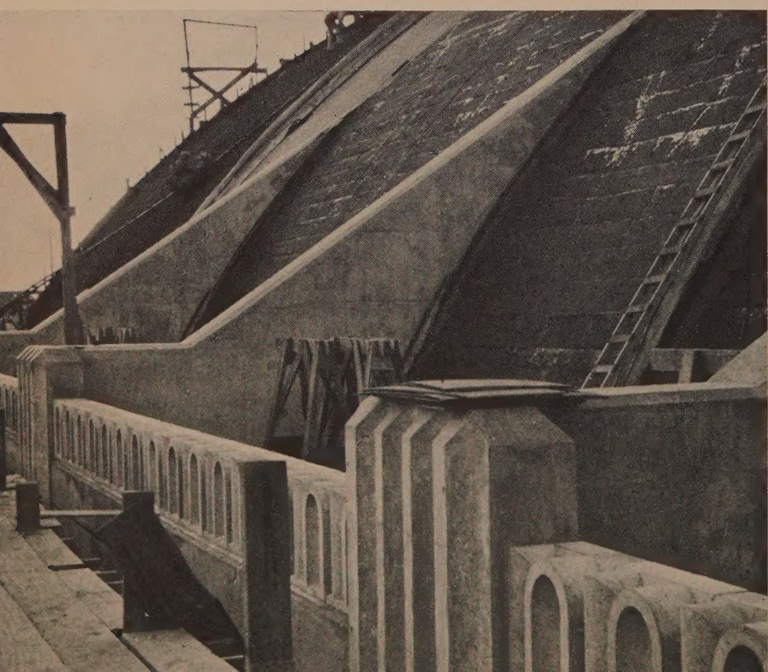
A refrigeration plant for making ice for the community and freezing the rink in the arena is located at the west end of the building. Brine pipes of 1¼-in. diameter are embedded 4 in. on center in a 4½-in. concrete slab which forms the arena floor. These pipes were supported on metal chairs while concrete was placed around them. Below the freezing slab is a layer of 3-ply waterproofing, 4 in. of cork insulation set in asphalt and a 6-in. reinforced concrete slab resting on long concrete beams originally placed longitudinally in the floor to support the scaffolding.

Lighting for the structure is accomplished by means of three great lightoliers each containing 47 lamps of 1000 candle power. This system gives 40 ft. candles at ice level, at least twice as good lighting as that of the average office building. Except for a bank of windows on the east end, the arena receives no light from the outside.

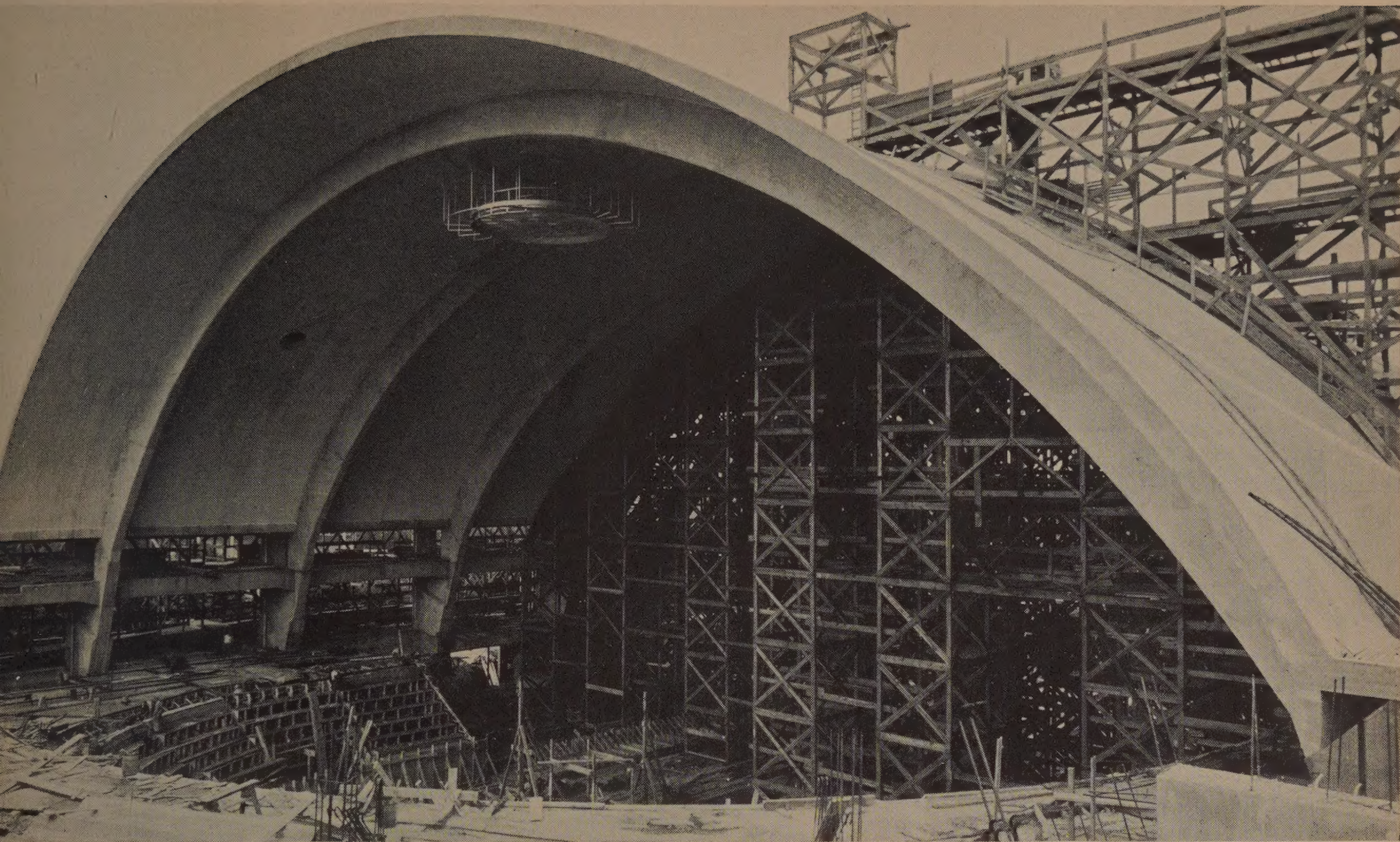
Loudspeakers are located in the center and one of the end light fixtures for announcements during hockey games. Both speakers, due to the cork lining of the ceiling, are clear and without distortion of any kind.

Choice of the type of construction for Hershey Sports Arena was based entirely on economy. Other types were considered, but the one chosen seemed most adequate when light distribution and other special effects desired were considered. In short, the Z-D system of concrete roof construction combined with architectural concrete walls gave what was wanted and most economically.

The design and construction was under the direction of the writer. With several Hershey officials we studied sports arenas in Canada and elsewhere, incorporating most of the desirable features into this one structure. Roberts and Schaefer Company of Chicago designed and supervised the roof construction with Anton Tedesko in charge of that work. Dyckerhoff and Widmann, originators of the Z-D system, contributed their knowledge of the effect of plastic flow on the correct shape of the roof. All the workers on the job were regular Hershey employes.



The increased depth of the arch ribs near the spring line made it necessary to carry them on the outside of the barrel shell—a structural necessity which also added architectural interest to the structure. The parapet detail was precast.



Two of the five roof sections were built when this photo was taken. Visible are three of the arch ribs and a cantilevered portion of the shell which is thickened at the edge. The scaffold supporting the roof forms is partially moved ahead for continuation of roof construction.

Z-D Shell Roof at Hershey

By Anton Tedesko*

HERSHEY Sports Arena roof, covering an over-all area of 245x356 ft., is of the barrel shell type known as the Z-D System. The hall proper covers an area of 232x340 ft., measured at street level. The load of the arched roof is carried to the footings by eight arches and two end walls. That the protecting roof slab is, in itself, the carrying structure, spanning between arches without help of purlins or beams, is the outstanding feature of this type of construction.

In order to re-use forms and centering, and to prevent high stresses due to uneven settlement of foundations, the roof structure was divided into five sections, separated by four expansion joints. Three intermediate roof units are alike, and the two end units are similar in design. The intermediate roof units are carried each by two arches spaced 39 ft. 2 in. on center. Thus the connecting concrete shell of 3½-in. thickness spans over a distance of 39 ft., and cantilevers 19½ ft. beyond each arch.

The cantilever ends of the roof shell are stiffened by ribs along the entire curve of the roof. End roof units are supported by one arch and by the end wall.

The arch frames were designed to be two-hinged, and since it was found advantageous to have the arches symmetrical, high foundation piers were necessary along the south side of the building where ground level is lower. The theoretical span of the arch between hinges is 222 ft. The rise of the arch above the hinges is 81 ft., although the crown of the arch is 100 ft. above floor level.

New ideas used in the design of this structure concern principally the 3½-in. thick cylindrical roof shell which is stiffened by its curvature and also by the carrying arches and the edge members near the horizontal boundary. With the shell thus prevented from flattening, it attains a carrying power far in excess of the capacity of a 3½-in. slab ordinarily used in bending. The roof slab of the Hershey Arena is almost entirely in tension and compression. It is really a 39-ft. girder span of great width and rigidity—like the upper part of a huge concrete pipe with a 132-ft. radius and with a high moment of inertia, it has to be considered as a whole, and its action is an action in space.

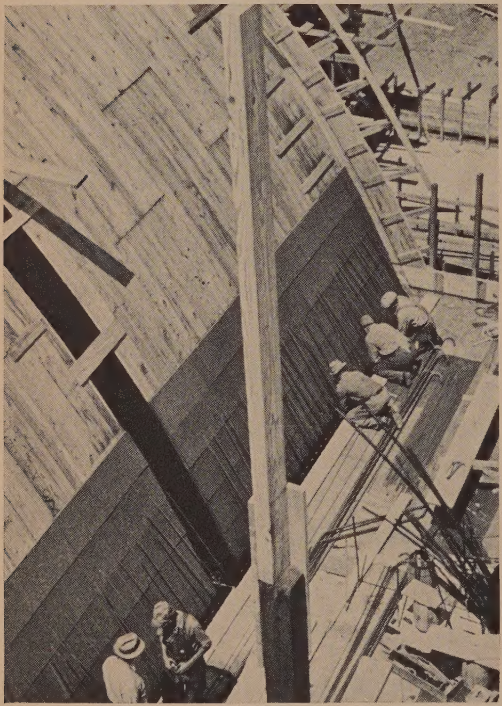
The reinforced concrete roof shell acts together with the arch and was placed monolithically with the arch by which it is restrained. Acting as a membrane which, because of its flexibility, can not resist bending moments, it is therefore subject only to direct stresses. Transverse bending

*Engineer of Structural Design, Roberts and Schaefer Company, Chicago.

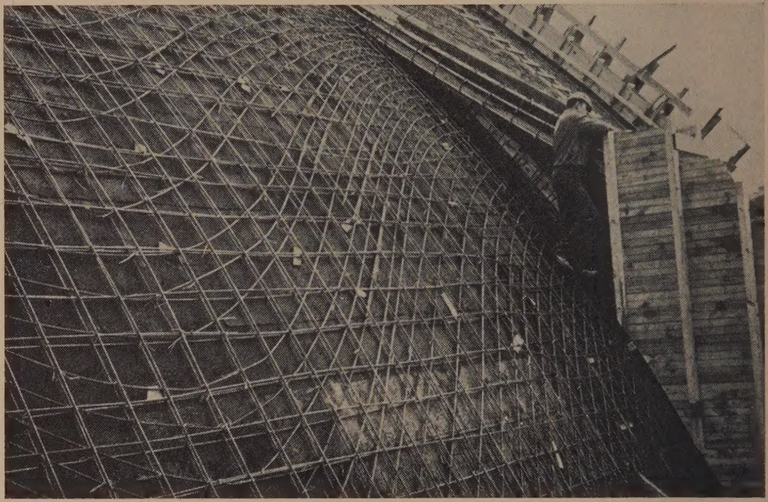
1. Reinforcing bars for hinge resemble a great fan.

2. Arch rib springings with connecting spandrel and walkway. Note hinges and opening through ribs.

3. Trusses for roof forms were laid and built on the ground.

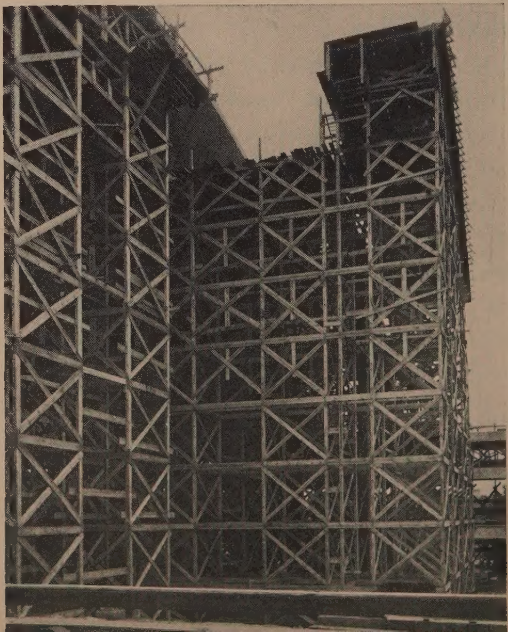


6. Cork insulation and acoustic ceiling were then added.

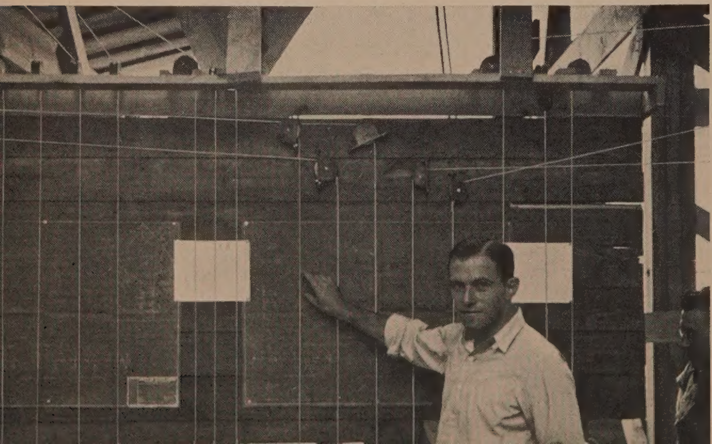


7. Reinforcing which ties the shell back to the arches resembles cable of a suspension bridge.

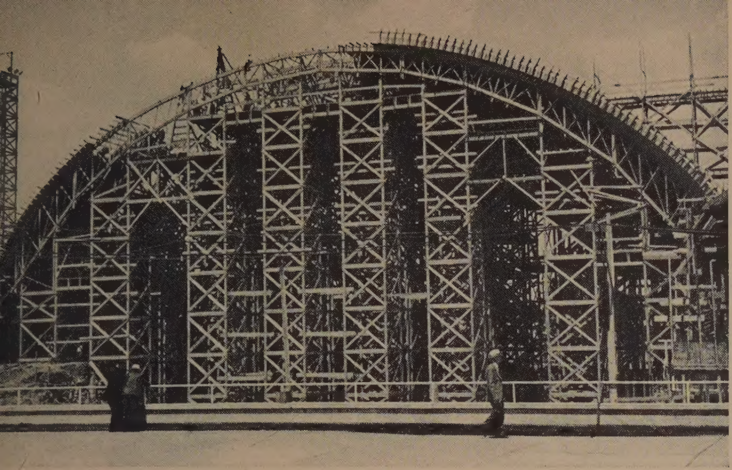
11. Half at a time, centering was pulled forward by block and tackle.



10. Wires from the roof to a central control station gauged roof deflection during decentering.



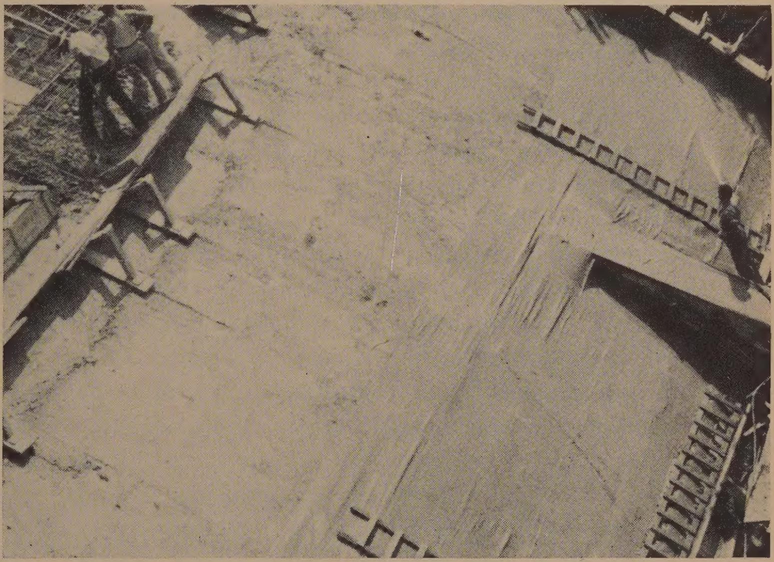
12. Th



4. Centering with trusses in place ready for roof forms. Between truss and scaffold are jacks.

5. The correct curvature of the roof form was checked with a templet.

8. Very stiff concrete was used for steep portions of the roof.

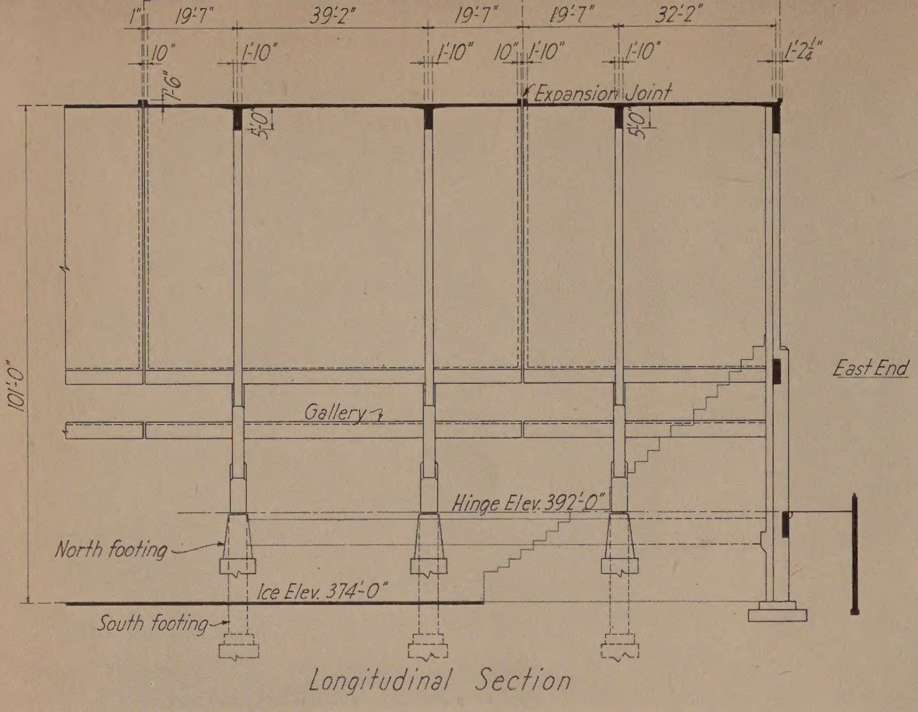


9. While placing of concrete continued, burlap was spread over the finished portion and water curing started.

angle iron shoes.

13. Pitch and insulating material for built-up roof covering.

14. Expansion joints were covered by copper flashing



fixtures, loudspeaker supports, fan house supports and the load of motors. A local strengthening of the lowest edge of the shell was also necessary.

Each of the arch frames is 1 ft. 10 in. wide, with a depth of 5 ft. at the crown increasing according to the increase in moment near the springing of the arch. Parts of the arch frame below the springing line of the roof have a width of 2 ft. 2 in., and openings are provided in these frames so that people may walk through them at gallery elevation.

The moments, axial forces and the shear in the arch frames were calculated for the dead load of arch and shell, for loads of roofing and insulation, symmetrical and unsymmetrical live loads on the roof, side slabs and galleries, and for wind pressure, suction, temperature stresses and shrinkage. Stresses due to elastic and non-elastic deformation and movement of foundations were figured. The arches with their footings were designed so that a 1-in. settlement and horizontal movement of the footings would not cause excessive stresses.

moments occur where the thin shell is framed into heavier members, and near such edges of the shell the increase in stress is taken care of by a slight increase in the thickness of the shell. Near its lower portions the shell is comparatively steep and carries between the arch frames like a bunker wall carries between its supporting columns. Such a bunker wall is stiff and will rarely deflect in its plane—even under considerable loads. The members to which the shell is connected near its lower edge are comparatively shallow. If these members were not connected to the shell they would deflect considerably under vertical loads. Therefore, along the springing line where the shell is connected to its edge members, a tension occurs in the direction of the cross-sectional curve of the shell. This clearly shows that the action of the shell is entirely different from an arch action because, in the case of an arch, one would expect compression due to thrust at the springing line, but not a tensile force. The shell hangs between the supporting arch frames and the stresses occurring under various loads necessitated placing reinforcing bars as shown in the illustrations. These reinforcing bars tie the weight of the shell back to the arches and are suggestive of the shape of cables of a suspension bridge. All tensile stresses in the shell are resisted by steel reinforcement.

Where the shell is under a "membrane stress condition" its reinforcing is simple and in two directions only. Where rim stresses affect the stress distribution, additional bars are provided at the correct angle in each point of the shell to take up the principal tensile stresses.

At some points the shell thickness was increased to 5 in. to provide for single concentrated loads such as heavy light

Snow load was assumed at 25 p.s.f. horizontal projection near the center of the span. Where the wind might pile up snow near the flat side roofs, the snow load was increased to 150 lb. A wind speed of 150 m.p.h., or 35 p.s.f. pressure, was assumed. Surfaces against the wind are subject to direct pressure, the surface on the lee side to suction. A temperature variation of +40 deg. and —90 deg. from that at which the structure was built was taken into account in the design. Shrinkage was figured equal to an additional reduction of temperature of 25 deg.

The shape of the arches was determined by the most favorable shape of the cross-sectional curve of the roof shell, which has a shape similar to an ellipse. For practical reasons, circles of three different diameters were substituted for a true ellipse. Near the corners of the arch frames where high negative moments occur, the increased depth of the rib made it necessary to lower the shell from the extrados of the arch and the rib was exposed outside the roof.

Reinforcing bars as large as 1½ in. round were required in the arch ribs. These large bars were spliced by means of threaded sleeves wherever the high tension in the concrete made it inadvisable to provide splices by overlapping only.

The hinges connecting the arches with the footings are a combination of the lead hinges as used abroad, and semi-hinges as recently discussed by American writers*. For the

*D. E. Parsons and A. H. Stang, *Proceedings A. C. I.*, Vol. 31, 1935; B. Moreell, *Proceedings A. C. I.* Vol. 31, 1935.

fan-like hinge bars 1 in. round reinforcing bars were used because they can more easily take the bending stresses due to rotation than could larger bars. To prevent plastic flow, the lead in the hinges is confined in angle iron frames and covered with protective paint. The hinges are surrounded by cork and asphalt for protection against corrosion and to make certain that no forces are transmitted between the arch and footing except at the point where the lead plates and hinge bars are provided. Near the hinges, the arch and footings are reinforced heavily to take care of the high vertical unit pressure. Footings of standard type rest partly on rock loaded to 8000 p.s.f., and partly on hard clay loaded to 6000 p.s.f.

The footings of the arches and the hinges were constructed in one operation. While the scaffolding was being erected for the arches, the lower part of the arches up to 30 ft. above the hinges was constructed in the usual manner in which columns are built.

For scaffolding, lumber was used which Hershey Lumber Products, the builders, could re-use on other buildings. Only short pieces were available, and due to many splices necessary the scaffolding was constructed much heavier than originally planned for lumber of greater length. The scaffolding was erected on angle iron shoes which rested on concrete runways. It consisted of towers with posts 12 ft. on centers. On top of the scaffolding towers screw jacks were provided to support trusses having the correct shape of the roof. The trusses supported joists, these in turn supported 4x8-ft. wood roof panels which gave the shape of the roof, the curve of which was checked by templets.

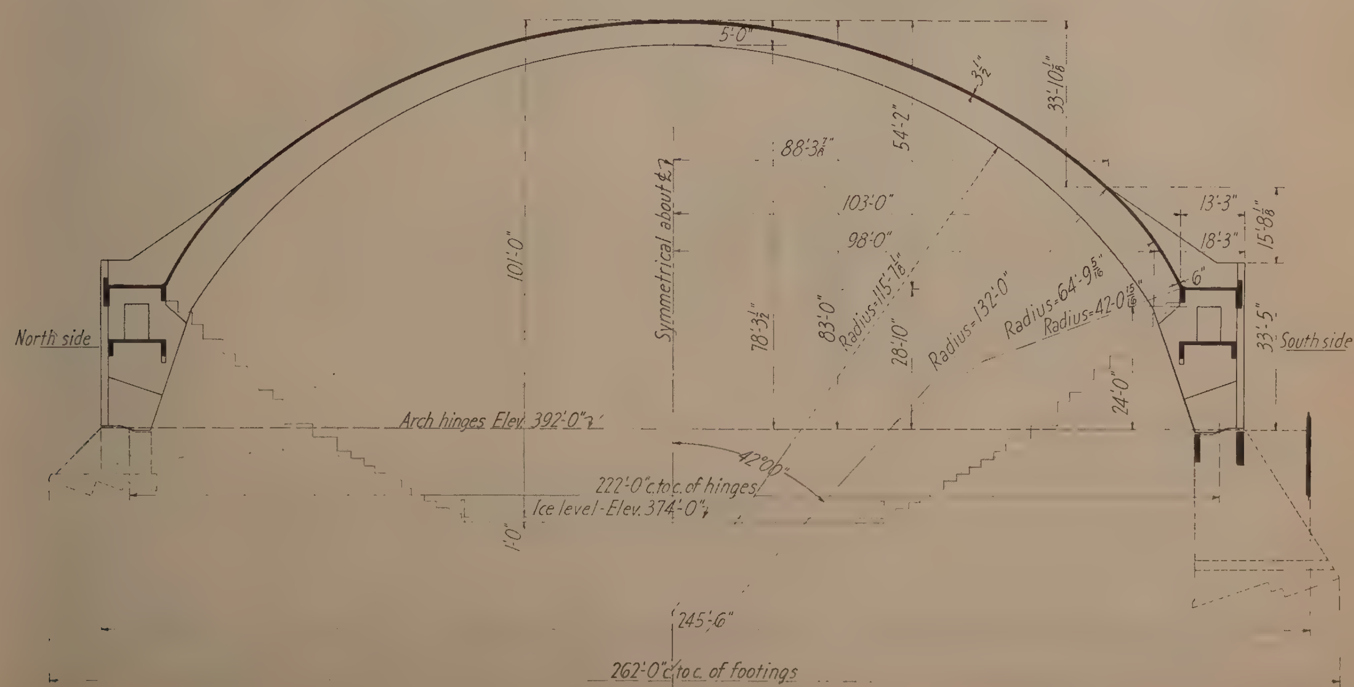
Tempered Presdwood was used to line the forms for the arches. The wood forms for the shell were covered with panels of 1½-in. acoustical-insulating cork which bonded to the concrete without aid of special anchors. Reinforcing rods were placed on top of the cork and concrete blocks were placed along the form surface to assure correct distance of reinforcing from the lower surface of the shell and also to assure correct thickness of the shell.

The decentering of each arch unit had to be done in a carefully controlled manner. For this purpose all 200 jacks supporting the trusses above the scaffold and the 20 jacks which deadlocked the hinges during construction time had to be lowered together gradually. Vertical wires attached to a number of points of the arches and shell were put under tension and brought over pulleys to a central point at the bottom of the scaffold. From there the decentering could be directed by telephone, the supervisor seeing at a glance how the complete arched unit deflected during decentering. The jacks were lowered one-half turn at a time, about ⅙ in. The arches deflected an average of 1¼ in., which is 1/2000 of the arch span. This deflection was within 5 per cent of the calculated deflection.

As soon as the arches were free from the centering the trusses were lowered and laid on top of the scaffolding towers, and the scaffolding was moved forward as explained in the accompanying article.

A continuous placement of concrete was made about once a month for the roof construction, the workers operating in three shifts. Evidence of the control kept on concrete mixes is that the first section of roof required 3,479 bags of cement and the third section only one bag less.

Wood blocks were set in the roof slab when it was placed, and to these 1-in. fiber board was nailed for additional insulation and subsequently covered with a built-up roofing. Expansion joints filled with elastic materials were covered with a sliding copper flashing.



Cross Section

Frame Analysis and the Structural Engineer

By A. J. Boase*

ENGINEERS have known from the time of the first use of reinforced concrete in building frames that its action was not that of a jointed material. Yet the design practice in general use has not taken full advantage of the inherently monolithic nature of concrete. That this practice is now on its way out and a more logical one is to take its place is evident, if the vast array of articles on analysis of continuous frames, appearing in technical publications, and recent changes in basic building codes are significant.

One might think the analysis of continuous frames a precocious modern child the way it has occupied—yes, demanded—the center of the stage of interest in building design. But such is not the case, as many of the fundamental concepts have come down to us through three-quarters of a century. On the foundation of tested and proved principles presented in scholarly papers for more than a generation, distinguished American scientists and engineers have developed many methods of frame analysis. The keen interest being taken in this subject is shown by the fact that 170 papers and discussions have appeared during the last five years in the *Proceedings of the American Society of Civil Engineers* alone. Today it is one of the most important subjects with which the designing engineer is confronted.

Usually as long as a subject is confined to academic discussions in technical journals, it does not directly affect the designer's office practice. The subject becomes important to him, however, when codes, such as the 1936 Building Regulations of the American Concrete Institute, require building frames to be designed for "moments and shears produced by dead load, live load and wind load, as determined by the principle of continuity."

Flexibility of arrangement, efficient distribution of materials and slender columns characterize the frame of the Tribune Building, Montevideo, Uruguay, designed according to principles of continuity. Valabrega, architect.

More recently, the progress report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete published in January, 1937, states emphatically that:

"In regard to elastic frame theory, the committee takes the position that the design of a monolithic frame as an aggregation of isolated members is no longer tenable."

The statement penetrates to the core of concrete building frame design. For many years, columns have been designed as compression members subject to axial load only, and beams have been designed by use of coefficients that include no allowance for important design elements such as concentrated loads, ratio of live to dead loads, ratio of span lengths of adjacent bays, ratio of column stiffness, and ratio of column width to span length.

It is recognized by the committee "that more exact methods of analysis are now available for general use in the design of buildings and other framed structures, also, that they may be simplified without undue sacrifice of accuracy."

Several practical, approximate procedures are available which will give good results in a quick, easy convenient manner and which are adapted particularly to regular office practice. It is neither necessary nor generally desirable to insist on the use of "exact" methods of analysis which, it should be remembered, are developed from assumptions that are approximate. The "exact" methods

*Manager, Structural and Technical Bureau, Portland Cement Association.

have an important place, to be sure, for analysis of unusual or irregular frames, but for all ordinary regular building frames, a satisfactory degree of accuracy may be obtained by use of procedures that are approximate and time-saving.

The Joint Committee, like the American Concrete Institute, has very definitely taken elastic frame analysis out of the realm of academic discussion and made it an actuality in regular office design by providing that:

> "In monolithic frames or continuous construction, the members of the frames should be designed to resist the bending moments and shears produced by the dead, live and wind loads in accordance with methods of elastic frame analysis."

The question of how to apply elastic frame analysis is not answered in code or specifications, but is left for the designer to decide and to learn from other sources.

Two publications appeared in 1915 which were to exert much influence upon subsequent developments in frame analysis. One was *Secondary Stresses and Other Problems in Rigid Frames*[1] by G. A. Maney, and the other, *Wind Stresses in the Steel Frames of Office Buildings*[2] by W. M. Wilson and G. A. Maney. In both these publications, the basis of analysis was what was later to be known generally as the Slope-Deflection Method, a method which was also treated in 1918 in the publication *Analysis of Statically Indeterminate Structures by the Slope-Deflection Method*[3] by W. M. Wilson, F. E. Richart and Camillo Weiss.

These publications contain a thorough and complete treatment of the problem and a full exposition of the exact solution by the Slope-Deflection Method. They deserve considerable study. In the *exact* solution, moments are determined through means of angle changes, or rotation of joints, and their determination by the procedure of this method depends upon the solution of n equations with n unknowns, n being the number of joints that may rotate.

To adapt the Slope-Deflection Method to office design, John E. Goldberg published an article in 1931, *Vertical-Load Analysis of Rigid Building Frames Made Practicable*[4] and in 1934 a paper entitled *Wind Stresses by Slope-Deflection and Converging Approximations*[5].

References to publications on the Slope-Deflection Method should include also *The Modified Slope-Deflection Equations*[6] by L. T. Evans, which gives an elaborate set of charts for evaluating the constants of the generalized Slope-Deflection equations for members with variable moment of inertia.

A newer method of frame analysis, known as the Moment-Distribution or Cross Method, is named after Professor Hardy Cross who in 1930 published the first general presentation of the method in *Analysis of Rigid Frames by Distribution of Fixed-End Moments*[7].

In this method, the joints are first considered artificially locked and all end moments are computed. The joints are then released and permitted to rotate, one by one, the rotation being caused by the difference between fixed-end moments. At each release, an adjustment is made in the moments at the joint while all other joints remain locked. This procedure is to be continued until there is equilibrium at all joints.

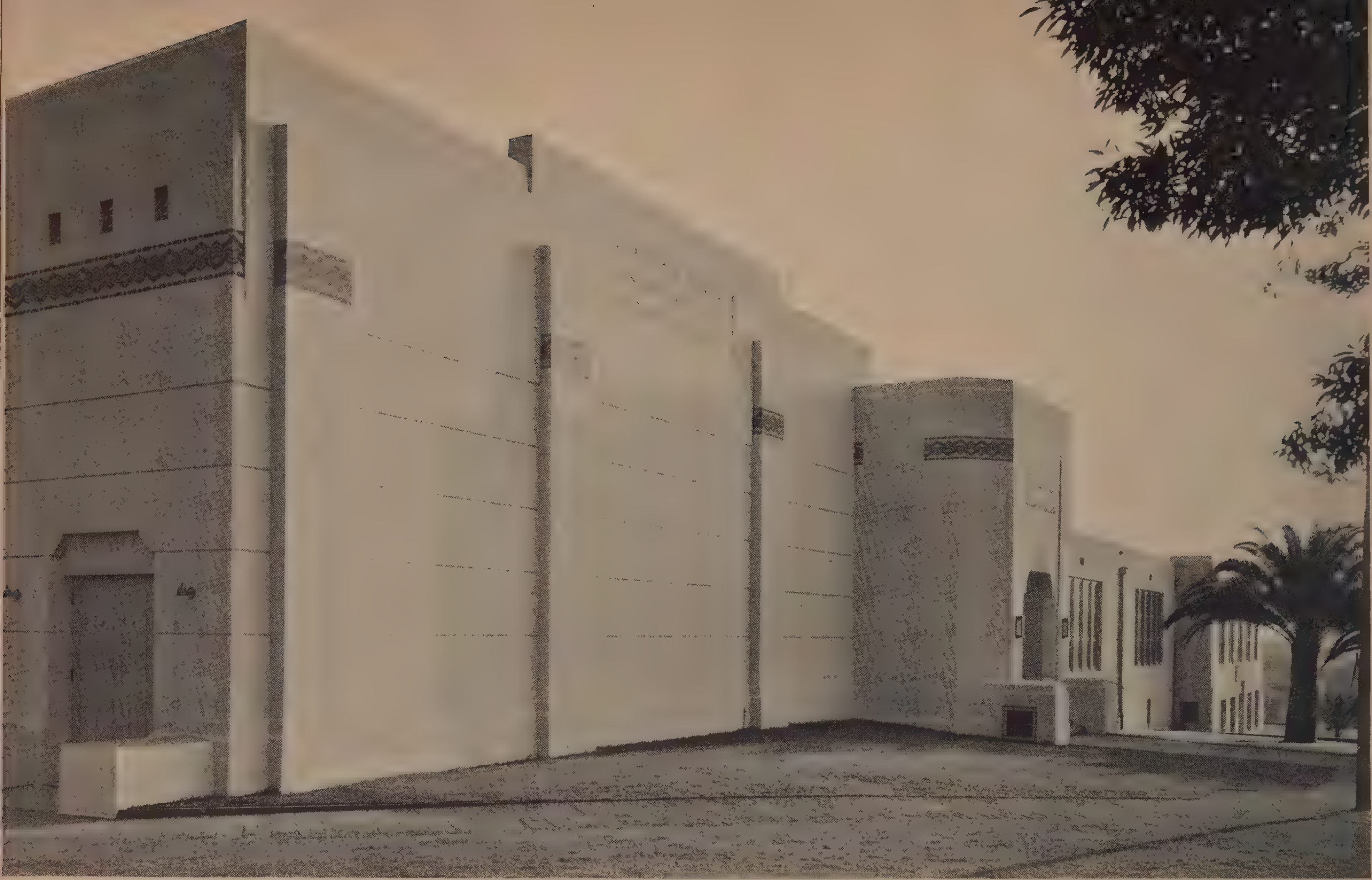
This ingenious method of rigid frame analysis has gained considerable recognition. It is an advantage that the designer who uses it sees at almost every step the physical significance of what he is doing. The basic principle of moment-distribution is subject to a great number of modifications, some of which have merit for special frame types or for solution of specific problems. Among these modifications are the "direct" or "precise" methods of distributing moments such as *A Direct Method of Moment Distribution*[8] by T. Y. Lin.

The Cross Method lends itself to modifications involving simplified procedures that give approximate results with sufficient degree of accuracy. For such a method, reference is made to *Continuity in Concrete Building Frames*,[9] in which the Cross Method—with minor modifications—is applied to distribution of fixed-end moments at *two* joints only. The result is that a satisfactory degree of accuracy is obtained with a considerable saving in time and effort for the structural engineer designing continuous building frames. This booklet includes also analysis of building frames subject to lateral loads (wind or earthquake), an analysis which, to a large extent, is a restatement or modification of analytical procedures proposed by Mr. Albert Smith in his two publications *Wind-Bracing Problems*[10] and *Basis of Design for Hurricane Exposure*.[11]

The references briefly discussed do not, of course, include all the important contributions to frame analysis. They contain merely those with which the structural engineer should have at least a passing knowledge to be familiar with the sources of informationon modern frame analysis.

BIBLIOGRAPHY

1 *Engineering Studies No. 1*, Univ. of Minnesota, 1915
2 *Bulletin 80*, Univ. of Ill., Eng. Exp. Sta., 1915
3 *Bulletin 108*, Univ. of Ill., Eng. Exp. Sta., 1918
4 *Engineering News-Record*, November 12, 1931, pp. 770-772
5 *Trans. A.S.C.E.*, 1934, pp. 962-985
6 *Proc. A.C.I.*, 1932, pp. 109-130
7 *Trans. A.S.C.E.*, 1932, pp. 1-156
8 *Proc. A.S.C.E.*, December 1934, pp. 1451-1461
9 Published by Portland Cement Association, 1935
10 *Jl. Western Soc. of Eng.*, February 1933, pp. 1-18
11 *Proc. A.C.I.*, 1931, pp. 903-924



Old Hermosa Beach School, considerably damaged by the 1933 tremors in California, was replaced by this architectural concrete building. Designed by Samuel E. Lunden, it was erected by T. P. Schultze, general contractor. Paul E. Jeffers, engineer.

Hermosa Beach School Reconstruction

By Samuel E. Lunden, A. I. A.

FOLLOWING the terrestrial gymnastics in southern California in March, 1933, the Hermosa Beach City School District found itself with a group of school buildings partially demolished and completely obsolete.

The main administration building with its auditorium and its flourish of Corinthian columns across the front still stood, columns and all—but apparently this was only in the spirit of bravado, for the structure was hopelessly wrecked. The adjoining class room building, although older and less

Smooth formed walls are not overburdened with detail whic is confined to simple reveals and occasional bands of sgraffit

imposing, withstood the shocks with the help of a few tie rods and could be used, with caution, pending the development of a reconstruction program.

First step was to transform the erstwhile auditorium into a pile of old lumber full of rusty nails, and a neat pile of bricks. This community, in common with many others, was embarrassed for funds and plans had to be formulated to make the most of the derelicts.

The main body of the administration building, shorn of its impediments, pediment and all, was found to contain a few sound partitions. The exterior brick walls were replaced in toto with concrete, and the first floor replanned to provide eight class rooms where four grew before.

The basement part of the original structure, left unexcavated for the most part and hidden behind a tremendous flight of steps, was found to lack only 18 in. of being a full story-height. The steps were carted off, dirt dug away and behold—there was comfortable space for the administrative offices, nurses' quarters, clinic, library and teachers' room. The orginal floor and roof were reinforced with light horizontal steel trusses.

The lumber pile which was once an auditorium gave up enough lumber to build the floor, roof and forms for two more class rooms at the east of the rehabilitated portion, the concrete exterior walls being continuous with the rebuilt part. This much completed and occupied, the old class room building with its faithful tie rods was at last razed and its site leveled for the new auditorium.

Hermosa Beach community is actively interested in drama, music and general adult education along cultural lines. It was felt that the auditorium should be suitable for these needs as well as for the school itself. Consequently, the structure was placed at the east end of the school with its lobby connecting directly to the main corridor as well as directly to the street.

The program called for an auditorium to seat 750 people, provision for full stage and movie equipment, fireproof and earthquake-resisting construction and architectural merit—all for less than $55 per seat.

After considerable head-scratching, an idea was evolved which would fit the program even down to the $55 per seat requirement.

Its specifications ran like this:

Floor—concrete slab on the ground, asphalt tile finish.

Walls—8-in. reinforced concrete walls between buttresses.

Roof—steel trusses, Junior I-beam purlins and 3-in. concrete slab.

Windows—steel sash.

Stage—normal proscenium and full stage loft, 52 ft. to grid.

Movies—projection booth suspended between last truss and end wall, thus saving floor space.

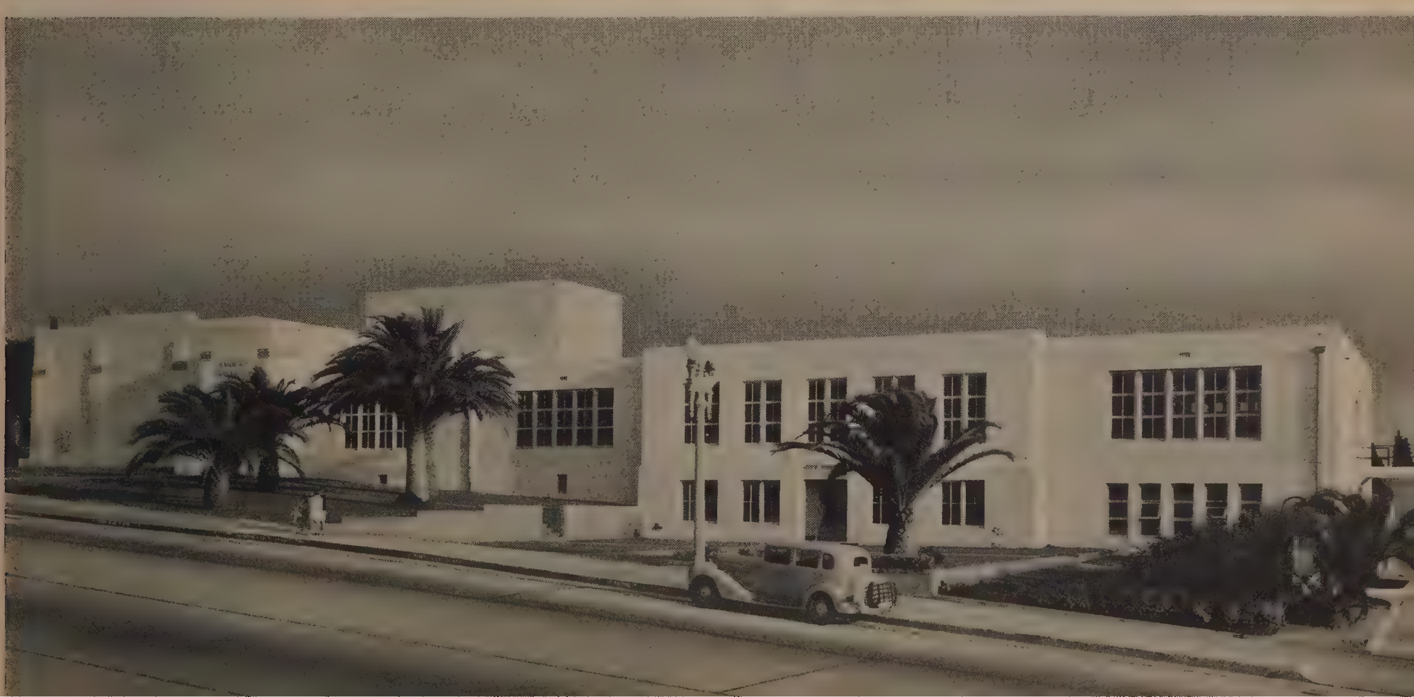
Acoustical treatment—hung hard plaster ceiling broken into an irregular surface to avoid undesirable reflections of sound. Side walls, acoustical plaster thin at the front and thick at the back; rear wall, acoustical tile.

Heating and ventilating—gas furnace with forced ventilation.

Lighting—indirect from fixtures.

This list of architectural virtues is really but a list of reasons why we should not dislike the structure. It assures us that the building serves its purpose, keeps out the wind and rain—but it has nothing to say about "architectural interest." A similar list and description of the architectural ornaments used would only indicate how much money was

Erected on a steep grade, the lower part of Hermosa School has two stories devoted to class rooms. The higher section contains the windowless auditorium, a single story structure with a high stage loft.



Concrete for exterior walls was left as it came from the forms except for a brush coat of white portland cement paint with color. The inscription over the front wall was cast in place. The letters above the doorway are aluminum.

spent on decoration, not how much architectural interest it has. Architects understand only too well that "architectural interest" is not a mere carved molding or a painted ornament which can be buttoned on a building like a silk shirt. It is a very elusive relationship between the obviously decorative features of a building and its physical, esthetic and financial aspects.

Following is a description of the architectonic devices which were used to try to endow Hermosa Beach School with that rare avis of distinction—architectural merit.

Exterior walls are architectural concrete as left by the forms, except for a brush coat of white portland cement paint with color. The forms were of ⅝-in. plywood with a horizontal V-joint occurring approximately 3 ft. on centers. A buttress treatment on the side walls expresses the truss supports. The buttress caps are decorated in sgraffito. Since the entrance lobby is at the side of the auditorium, the front wall is left free of all openings and is treated in the simplest manner with an incised inscription cast in concrete and flanked by buttresses. The projecting entrance feature carries ornamental bands cast in place. Above the entrance is the title, "Hermosa Auditorium"—done in aluminum letters 10 in. high and set out 2 in. from the wall.

The lobby, serving also as a passage to the court between the buildings, is of exposed concrete—walls and ceiling. Here the warm cream color of the concrete surfaces is in harmony with the deeper tones of the sgraffito. The entire group is designed as a unit, the horizontal bands serving to tie all parts together.

Paul E. Jeffers was responsible for the structural engineering work on the project. Construction was by T. P. Schultze.

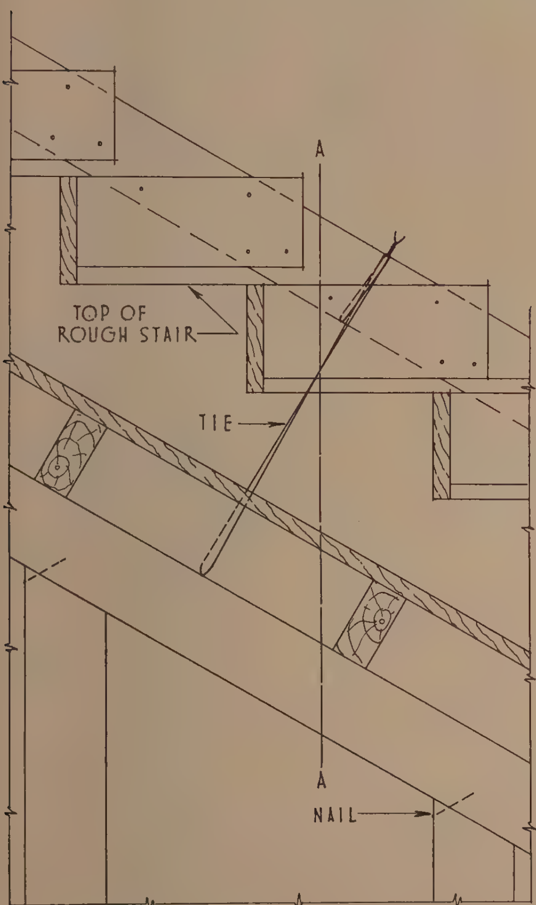
The warm cream color of the concrete walls and ceiling produces a bright, well-lighted passage between the two buildings which comprise the Hermosa Beach School group. Careful formwork was responsible for the even wall surface.

STAIRS

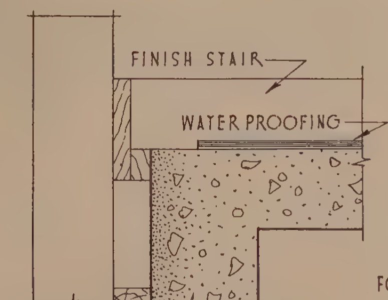
ALTHOUGH the construction of stairs is primarily a part of the structural concrete work of the job, appearance is a factor, and frequently stairs adjoin walls; so their construction becomes also a part of the architectural concrete. The problems presented in stair construction will differ somewhat from one job to another, but the general principles do not differ greatly so a few typical examples will suffice to illustrate common practice. It is true that almost any flight of stairs might be constructed in more than one way with equally satisfactory results. The details for the four examples shown do not necessarily show how these specific stairs were constructed, but simply illustrate one satisfactory method.

A stair like that shown on this page is conveniently constructed in two operations. The supporting walls and a rough stair slab is built first. The rough slab is usually designed to carry the dead load of the stairs plus the superimposed load and serves as a base on which to place a membrane waterproofing to insure the space beneath the stairs being dry. The waterproofing should be continuous the length of the flight of steps including the landings. It must also be turned up to the top of the finish stairs in the chase in the build-

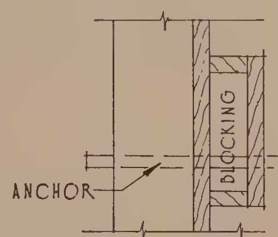
EBELL CLUB, LOS ANGELES, HUNT AND BURNS, ARCHITECTS



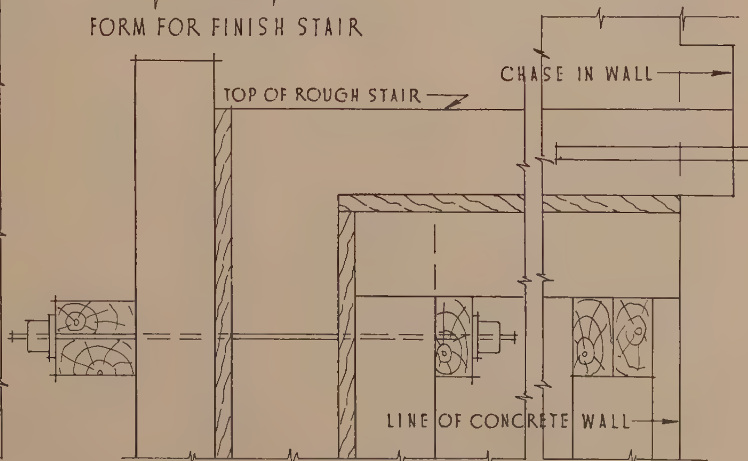
LONG SECTION OF FORM FOR ROUGH STAIR



FORM FOR FINISH STAIR



FORM FOR CHASE IN WALL



SECTION ON LINE A-A

FORM FOR WALL AND ROUGH STAIR

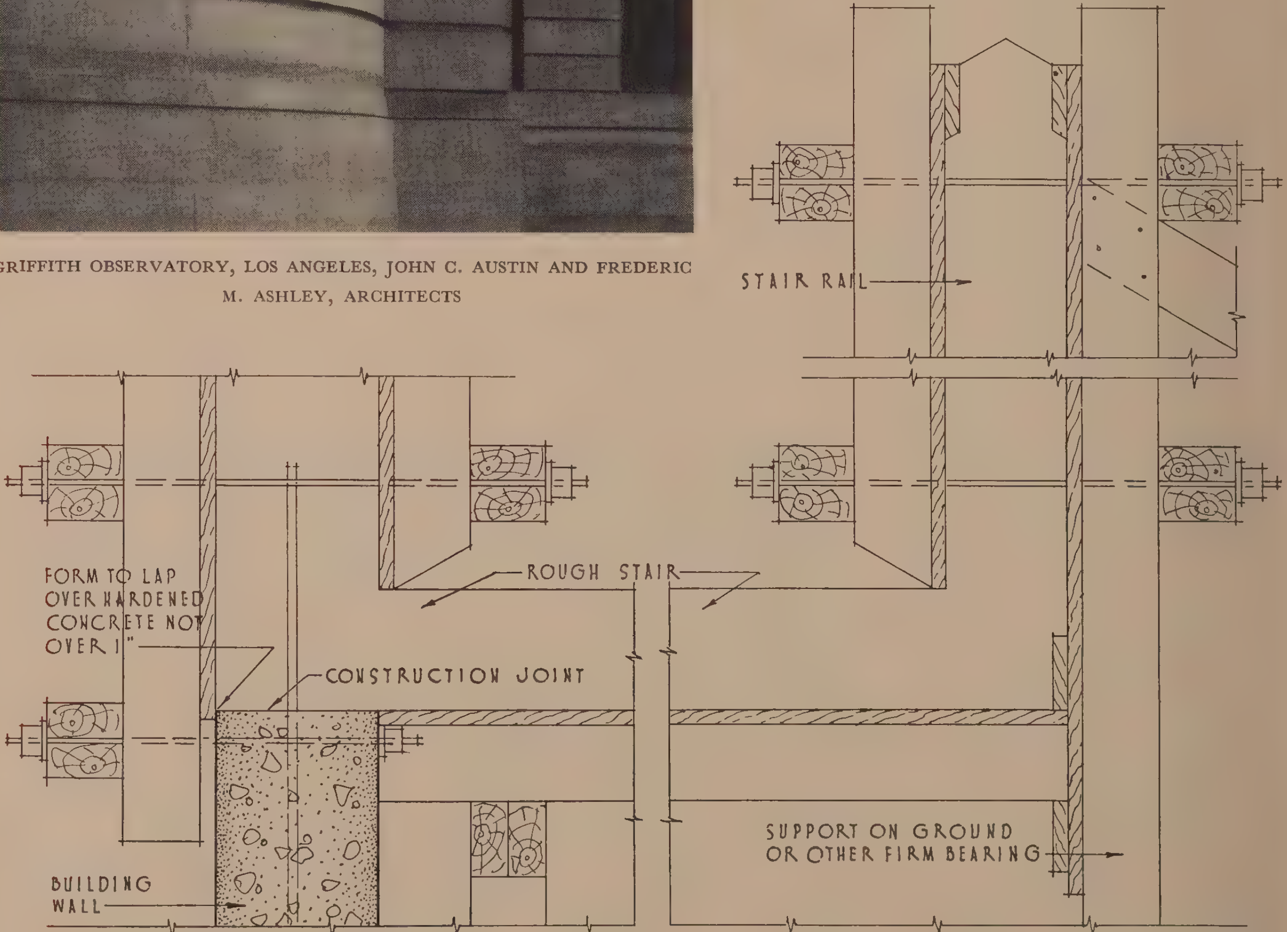
ing wall to prevent leakage around ends. After the rough slab is completed and the waterproofing is in place, the concrete for the finish stairs is placed. The thickness of the finish over a membrane waterproofing should not be less than 2½ in. A 6x6-wire mesh should be provided in the finish for reinforcement.

Struts supporting the bottom form for the slab should be set plumb. They need only to be lightly nailed to the stringers to hold them in position until the load is placed on them. Double 2x4's or single 4x4's are generally used for struts and stringers.

The top form should be supported from 2x4-stringers about 3 ft. apart. To prevent floating, the top form must be tied down. Scabs holding the boards forming the risers should be kept above the level of the treads so the concrete can be struck off.

It is not often that a cantilever stair such as that illustrated on this page must be built, but it is well to consider the problems involved. A convenient method is to locate a construction joint in the wall at the bottom of the stair slab. The joint

GRIFFITH OBSERVATORY, LOS ANGELES, JOHN C. AUSTIN AND FREDERIC M. ASHLEY, ARCHITECTS



FORM FOR CANTILEVER STAIRS

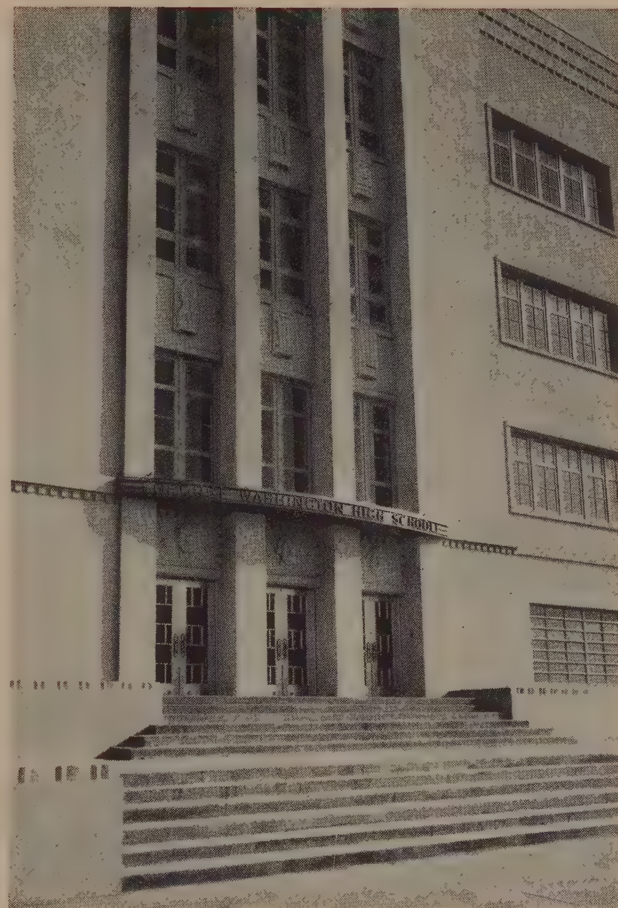
should not be at the top of the slab because of the possibility of leakage due to water running down the steps and standing against the joint.

The wall above the construction joint as well as the stair slab and railing can be cast in one operation. Note especially that the inside form for the wall overlaps the hardened concrete not more than 1 in. and is drawn tight against the concrete with a tie rod just below the joint. The studs for the outside wall form and the inside form for the railing should be chamfered to permit striking off the concrete for the rough slab. After the rough slab has hardened and other work in the vicinity of the stairs has been completed, the finish for the treads and risers can be placed. This finish, which is bonded to the rough slab and not placed over a membrane waterproofing, need be only 1 in. thick, but should never be less.

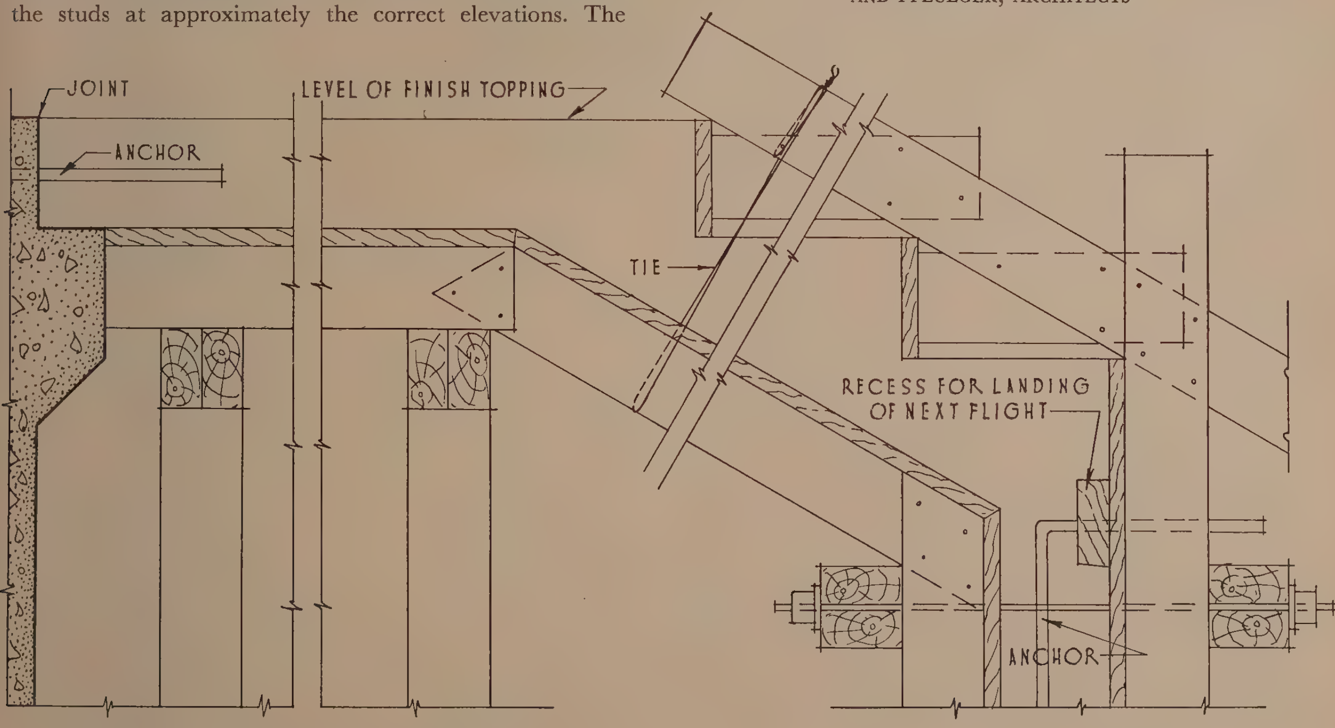
Broad entrance steps may make an effective approach to a building or an unsightly one, depending upon the construction methods used.

The principal problem involved in construction of stairs such as illustrated on this page is to prevent unequal settlement. Buttresses or cheeks and any foundation walls for the stairs must be carried down to the same level as the building foundation, unless they bear on natural undisturbed soil. It is courting trouble to build stairs on fills next to a building foundation.

Circular stairs like those on the next page appear complicated to build, but the problem is actually quite simple. Two floor rings having the diameter of the inside and outside of the stair, with proper allowance for the studs, are made up of double 2x6's. At the top only an inner ring is necessary to hold the studs in alignment. Short sheets of plywood to form the outside of the curb are then nailed to the studs at approximately the correct elevations. The



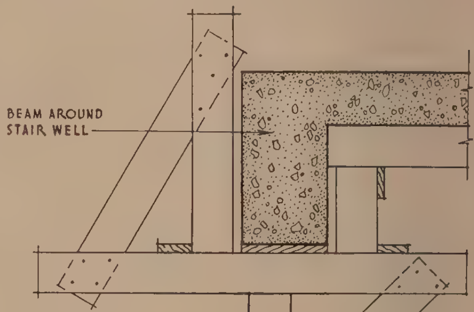
GEORGE WASHINGTON HIGH SCHOOL, SAN FRANCISCO, MILLER AND PFLUEGER, ARCHITECTS

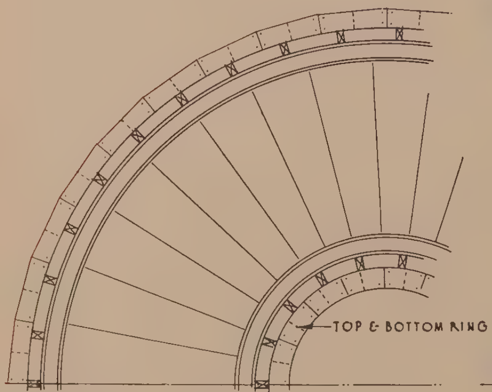


FORM FOR PLATFORM AND STEPS

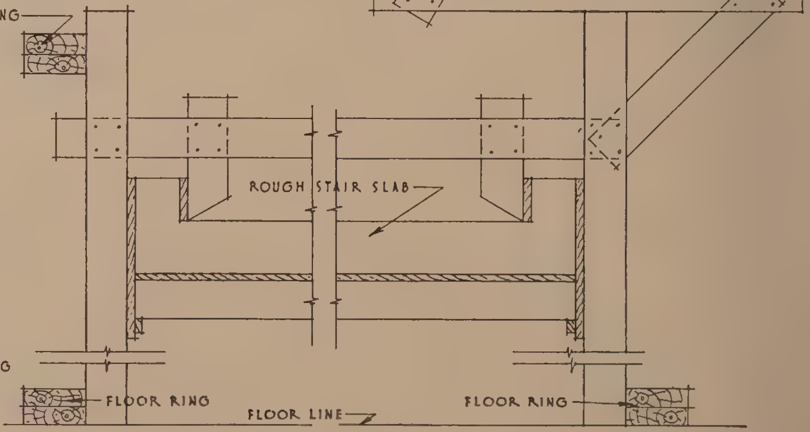
CAMILLE SEE GIRLS SCHOOL, PARIS, M. LE COEUR, ARCHITECT

location of risers are then marked out on the floor and plumbed up to the correct height for the treads, thus establishing the slope of the stairs. The position of the soffit of the slab is then easily located by measuring off the required thickness of the slab from the reentrant angle between the risers and treads. Because the soffit presents a warped surface, narrow rippings 1 in. to 1½ in. wide must be used for form sheathing. The inside forms for the curb are suspended as shown in the detail.





PLAN OF FORM FOR STAIR
FORM FOR CURB IS NOT SHOWN



FORM FOR STAIRS

Cleanly executed flutes and molded bands characterize the architecture of the new building erected last year for the Mid-South Cotton Growers at Memphis, Tenn. Walk C. Jones and Walk C. Jones, Jr., were the architects with Gardner and Howe, structural engineers, and S. & W. Construction Company, contractor.

Mid-South Cotton Growers Building

By Walk C. Jones, Jr., A. I. A.

THE design of the new Mid-South Cotton Growers Association building is the result of complete cooperation between the owner, architect, structural engineer and contractor during the planning of the project. Through frequent conferences among these parties during preparation of the plans, the cost of the building was held to a minimum. At the completion of the plans and specifications, the contract was awarded to the S. & W. Construction Company on a profit-sharing basis with a guaranteed cost. This contractor was selected at the beginning by the owner. We stress this procedure in the planning of a concrete structure, for if care is not exercised by the architect in planning, he will be alarmed to find his costs running beyond his budget. Concrete can be unnecessarily expensive if improperly designed, particularly as to ornament and finish.

The Mid-South Cotton Growers Association required a building that would be dignified and would impress the public favorably—at the same time, a building that could be erected at a reasonable cost. For these reasons, concrete was employed.

Considering monolithic concrete construction as a modern medium of construction, we endeavored in the design to depart from traditional forms of ornament. It was desirable, however, to avoid extremely modernistic forms. We wanted to design a modern building, with a modern material, but to do this with classic feeling and repose. Architecturally, the building is of no particular style or period. If urged to designate a style, it might be called an adaptation of modern forms, reflecting the influence of the classic.

Lines and detail are quite simple. Not only was this considered a matter of good taste, but there were practical reasons, too. In consultation with the contractor, it was determined that if architectural details on the exterior were made so they could be molded with standard wood shapes, construction operations would be much easier and less expensive. Stock lumber sizes could be used thus reducing

millwork to a minimum. Each detail was consequently studied to fit this condition. Little additional effort is required in making these studies. It is not difficult to do, but it is extremely important in controlling costs. It is quite as easy to make an offset ⅞ in. as 1 in., or 1⅝ in. as 2 in.

It was discovered also that by using concrete these simple shapes and lines could be used in pleasing details not economically possible to execute in any other medium. This fitted our problem—a modern exterior at low cost.

The structural engineer, in collaboration with the architect, studied the structure from the standpoint of simplicity in construction. The outer framework was incorporated in the outer wall. In short, the outer wall not only acts as an

Instead of trying to modernize three old buildings on this prize location, the Cotton Growers chose a new building in concrete at a cost but 10 per cent higher than estimated for modernizing.

enclosure, but as a part of the structural frame as well.

The building is nearly square in plan, occupying an area 75 x 78 ft. This permitted practically square spacing of columns, allowing a flexible and variable combination of rental areas on the grade floor. It was decided to design the floor as a two-way solid slab, with each panel supported at its sides by beams running between the columns. Such a design was about as economical as any other. In addition, it permitted the contractor to line the floor forms with smooth panel board, thereby producing a ceiling requiring only a coat of paint for its final finish.

As finally carried out, all interior structural members—beams, columns and floors—are exposed concrete. The only treatment given, aside from painting, was light rubbing and filling of such air holes as existed on the surface after form removal. As may be judged from the illustration showing the interior of the shoe store on ground level, the effect was pleasing. And it proved highly economical.

Of possible interest might be the method of handling the lettering on the parapet wall. In detailing, each side of the building was laid out to a scale of 1 in. equals 1 ft. The exact shape of each letter was laid out accurately to 1⁄16 in., and the distance between the letters likewise accurately dimensioned. Then, each individual letter was drawn to full size, the mill employing the drawings as templets for forms of ¾-in. plywood. The edges of the cuts were slightly beveled to permit easy removal from the concrete and to produce highlights and shadows on the letters.

The parapet is somewhat higher than required on the average building; but it conceals three large cotton-classing skylights on the roof and adds, we think, to the exterior appearance of the building which is located on a prominent uptown corner.

Exterior treatment of the first floor walls comprises small vertical flutes about ⅝ in. wide. This produces a soft-appearing texture similar to tooled stone surface and forms a base for the building. However, we discovered this detail is too small for best construction practice and we would probably hereafter use a ⅞-in. flute for similar purposes. Other details are as indicated in the sketches, molded

against milled wood forms, except the flat surfaces which are cast against plywood. All surfaces were given a light, wet rub with a carborundum stone to effect uniform color. A black glass dado at the sidewalk line completes the exterior architectural effect.

C. G. Henry, representative of the owner of the building, and Gardner and Howe, structural engineers, cooperated splendidly with the architect and the contractor.

New Building—For 10% More Than Modernizing

By E. E. Schmied*

DURING the early part of 1936, the Mid-South Cotton Growers Association, a progressive cooperative organization of cotton farmers with headquarters in Memphis, began definite steps to secure a new home. At the corner of South Front and Monroe Streets they located a desirable site encumbered by three old buildings of the nondescript type that characterizes the older business streets of most cities. As they stood, the buildings were not suitable for the needs of the Mid-South organization, but the location was ideal—in uptown Memphis, on a high prominence overlooking the Mississippi River, providing plenty of air and light. The latter is of importance in cotton sampling. Negotiations were closed for this location, and decision was made to remodel the existing structures.

We, as contractors, were asked by the owner to estimate the cost of such improvements in accordance with their plans. We did so; but after studying the plans, we advised the owner that for a sum of approximately 10 per cent more than the cost of remodeling, the old buildings could be torn down and replaced by an entirely new one—a building that would be in every way more suitable. Space would be designed to fit requirements and not the limitations of the existing construction. It would be completely firesafe and would require a minimum of maintenance as compared to operating a makeshift structure. Again, a new, fresh exterior elevation could be presented reflecting the progressiveness and stability of the association. Yes, we offered this for 10 per cent more than the cost of remodeling.

We expected the owner's reaction to be one of skepticism, but undoubtedly he would be interested in listening. We were prepared to back our point.

In many years of building experience, we had been impressed by the cost added to a new building by the wide variety of materials used in construction. Particularly was this found true in the case of smaller structures where the overhead charge and non-productive time of mechanics was large, created by numerous subcontractors and miscellaneous mechanics making small installations. Often the cost of items was found to be out of proportion to the value they lent to a building.

Ceilings in ground floor store are exposed concrete.

In addition, more from custom than from need, many items of trim and refinement were too often included which had little utility and doubtful esthetic value. Therefore, why not reduce the number of materials needed on a job to an absolute minimum and eliminate all features of no value?

We had noticed for several years the wide strides being made in the uses of concrete, meanwhile putting many of these uses into practice in our own work. We were aware of the versatility of the material and its many practical advantages, and since we were endeavoring to keep the number of materials to a minimum, why was not concrete the answer? We could find no other fireproof, durable material that could serve for structural frame, floors (including surface finish), walls and architectural treatment.

In concrete construction, sand, gravel, cement, steel and lumber form the bulk of materials to be purchased. Carload lots can be secured, insuring lowest prices. The overhead cost of setting up a concrete plant is practically the same, whether for installing a foundation or for constructing an entire structure of concrete.

Concrete is a plastic material. It is a simple and economical operation, when constructing forms for the structural frame, to enlarge and shape the outer forms to fit the desired exterior architectural scheme. With but one operation, outer frame, wall and architectural decoration are produced. By providing a smooth interior surface for the walls, paint can be applied directly to the concrete in climates where furring is not necessary.

With smooth window jambs and sills of concrete cast at the same time as the wall, there is no need for further trim at these points—another important saving. Sheet metal work at the roof may be reduced by 95 per cent.

It was with arguments such as these that we went to the owner to support our claim that we could build a new structure at very little more than the cost of remodeling.

Convinced that the proposition had merit, the owner engaged the architect to prepare the design, based on a full use of concrete. The building attests the results of close cooperation between the architect and contractor and all others connected with the job.

Our firm was given the contract and the building was erected at a cost within the original estimate. This amounted to $60,000, or 25 cents per cubic foot, complete.

*President, S. & W. Construction Company.

First earthquake-proof building erected by the Federal government is the new post office and custom house at San Pedro, Calif. With floors and walls of reinforced concrete, it was designed by the Procurement Division, Treasury Department, Louis Simon, supervising architect and Neil A. Melick, supervising engineer. George A. Geib was construction engineer on the project and Sarver and Zoss were contractors.

San Pedro Post Office—Construction

By George A. Geib*

THE new post office and custom house, recently erected at San Pedro, Calif., an earthquake-resisting type of building, was designed according to the most modern theory of structure analysis; and, taking advantage of concrete's adaptability to simple lines, its architecture follows modern trends. This simplicity of line and detail, depending upon large masses and broad planes for effect, greatly emphasized the need for first-class architectural concrete work.

This same simplicity also permitted repeated use of forms and a ready check on form alignment. With two such important factors for success and economy in a concrete job thus determined by the design, and with careful attention given to mixing and placing the concrete, a highly satisfactory job resulted.

In a building of this size—246 x 86 ft., three stories and basement—one of the main considerations in planning the progress of the work was the location of construction joints. Only four desirable locations for vertical joints were possible in the front wall, and these were at each inside corner of two offsets. The rear walls offered but two. Thus the concrete had to be placed in three sections, each about a 10-hour run with the size mixer used on the job. The horizontal construction joints were fixed by the specifications and plan requirements at the top of the spandrels.

*Construction Engineer, Procurement Division, Public Buildings Branch, Treasury Department.

In order to provide deep reveals, the exterior walls are in general 16 to 20 in. thick and are reinforced with a double curtain of horizontal and vertical bars spaced 8 to 10 in. on centers and 2 in. from either face of the wall. At the corner of each window and door opening, three rods were placed to resist diagonal shear. These diagonal bars intersecting the horizontal and vertical steel around the openings almost completely filled the space between the forms, making it rather difficult to place the concrete or to puddle it after it was placed. When the concrete was allowed to drop from the top of the forms, there was a tendency for the heavy aggregates to bounce off the diagonal rods, thus forming pockets and bad honeycombs.

As soon as this condition was noticed, a long tremie was made of 16-gauge sheet metal, 3 x 8 in. in cross section, in 4-ft. lengths. This was used to place the concrete to prevent a separation of the aggregates. As each lift increased in height, a section of the tremie was removed, care being taken that there was no appreciable drop from the end of the tremie. The tremie proved to be a helpful device in placing the concrete at all critical points.

Each wall lift was started with about 4 to 6 in. of grout on the lift below along the whole length of the day's run. This was followed by the regular mix in layers about 2 to 3 ft. deep. Chances for blow-outs were thus eliminated as the pressure on the forms was applied gradually and was never very great. Placing the concrete in this way permitted a constant check on form alignment which, perhaps, was one of the principal factors in securing sharp detail.

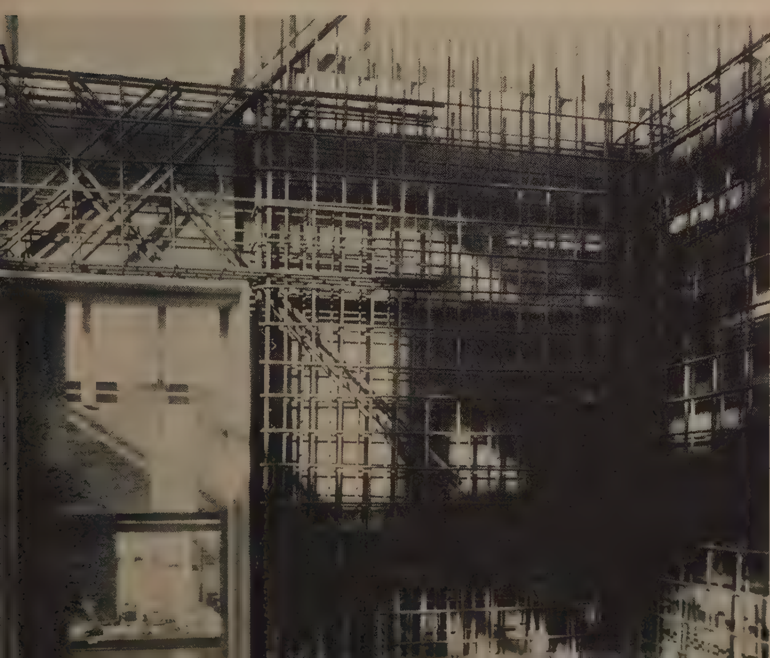
Vibrators were used in placing the concrete for floor slabs and beams, but they were not used on the exterior walls because it was believed that a better surface texture could be obtained by hand methods. All puddling on the exterior walls was done by hand, and the men were watched closely to see that they kept moving; that is, so they would not puddle too long in one place.

Sieve analyses were made of fine and coarse aggregates before the job was started, to determine the best mix. The workability and plasticity of the resulting mixture was watched closely as the concrete was placed in the footings and basement walls. Slight variations in the gradation of materials were made, depending upon the fineness of the sand. From 1 to 4 per cent of pit-run unwashed sand was added at times, replacing similar amounts of washed sand, in order to assure desired plasticity. Very slight variations in water content of the mix were made to secure necessary workability of the concrete for placing around heavy clusters of steel. The slump was about 6 in.

The plant consisted of the common type of skip and hoist, with a storage hopper placed on each floor as the job progressed. Rubber-tired buggies were used for transporting concrete from hopper to forms, which reduced shock on the runways and the tendency of the heavy aggregates to settle to the bottom of the buggies.

To achieve the best results in architectural concrete, tight and rigid forms are essential. On this project 2 x 8-ft. 5-ply panels of plywood were used for form sheathing for all exposed exterior and interior walls. The joints between all panels, however tight, were pointed with a putty compound of 50-50 tallow and cement after the plywood sheets were securely nailed. A minute inspection of the nailing in every panel was then made, since there is always a possibility that a carpenter might not use the proper number of nails. A loose panel will make an unsightly bulge or get out of line with its neighbor, thus forming a bad projection on the finished face of the concrete. Pointing of the joints prevented the escape from the concrete of water needed for hydration of the cement. Furthermore, it prevented messing and staining of the forms or finished concrete below.

All form studs were placed on 12-in centers. The wales



To provide deep reveals, the walls are from 16 to 20 in. thick and contain extra-heavy reinforcement to resist earthquake stresses.

were made doubly secure and spaced 12 in. apart at the bottom of the forms to prevent distortion. Form bolts were used in lieu of wires; in fact, ordinary tie wires were not permitted on the project. Wooden wedges were firmly driven at the bottom of the forms against the hardened concrete below to prevent any offset of the concrete above. In general, the forms followed methods outlined in *Forms for Architectural Concrete*.*

On account of slight variations in the color of the exterior walls, a cement wash was decided upon to blend the whole surface of the walls, including plugged bolt holes and small patches. This wash consisted of fine sand, white portland cement and an admixture consisting of 1 pt. of calcium chloride to 5 gal. mixing water. These ingredients were mixed into a heavy paste and applied to the surface of the concrete.

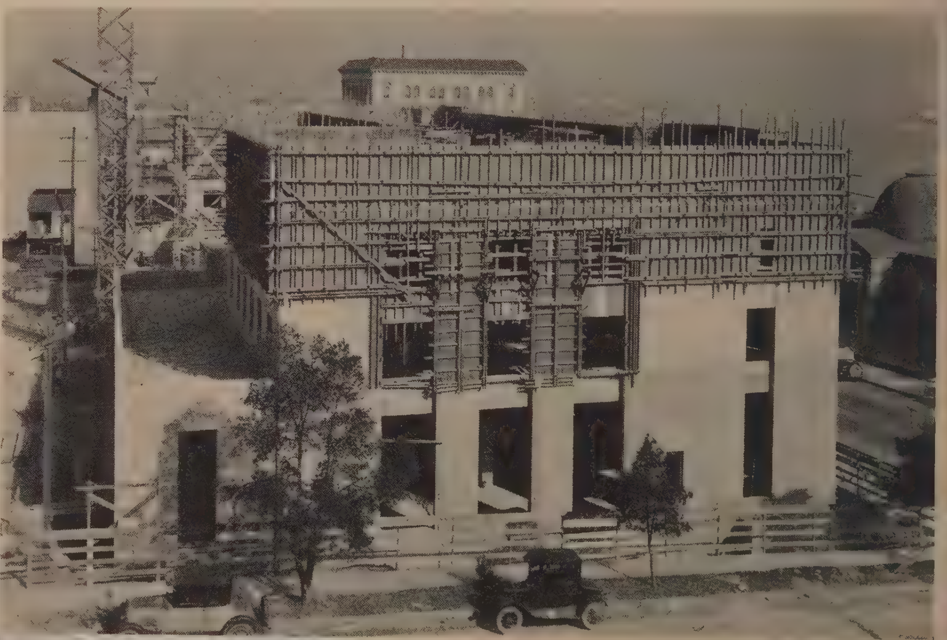
All concrete surfaces to be treated were first thoroughly brushed with a medium-fine wire brush to remove the laitance and dust. A certain amount of oil from the plywood panels always clings to the concrete. This also was removed by wire brushing. When the laitance film was completely removed, the whole was washed down with a hose and, when slightly moist, the cement paste was brushed on with a soft brush. The paste was rubbed into the pores of the concrete with a cork float, thus closing and sealing all marks, bolt holes, honeycombs and other slight imperfections. The surplus paste was rubbed off with a gunnysack, and after 24 hours the finished concrete surface was given a washing with clean water—a light sprinkling, not a heavy stream. In this manner the natural wood grain of the panels was not altered or covered, leaving the wall with all the desired characteristics of architectural concrete, yet eliminating unsightly imperfections.

Good results in the use of architectural concrete require perfect teamwork and cooperation between all parties—the inspection engineer, superintendent and his working crew. Common sense and an experienced eye will often accomplish what specifications and rules alone cannot. Every chance must be given concrete to allow its best behavior to come forth. Familiarity with concrete and its handling will suggest necessary variations in design of mixes that will improve workability and secure better results.

Such procedure was adopted on the San Pedro project; and it was due to this close cooperation between the contractor, Sarver & Zoss, Inc., Los Angeles, their superintendent, Ted Carson; the carpenter foreman, Alec Henderson; the men on the runways, and the writer, that the results here obtained were outstanding and satisfactory.

Plans were drawn by the Procurement Division, Public Buildings Branch, Treasury Department, Washington, D.C. under the direction of Rear Admiral Christian Joy Peoples, Director, and W. E. Reynolds, Assistant Director.

*Published by Portland Cement Association.



Careful workmanship and good formwork were characteristic of the San Pedro post office job. Here are shown well-aligned forms, above, and the floor reinforcement, below.

lthough it looks like wood, Union Pacific Railroad's Sun Valley odge at Ketchum, Idaho, is entirely reinforced concrete—molded and ained to represent natural timber. W. T. Wellman, UP architect, esigned the details with G. Stanley Underwood of Los Angeles re-ponsible for original sketches. J. V. McNeil was general contractor.

Designed for Zero

By Archie J. Baley*

LAST winter scouts of the Union Pacific Railroad reported to W. Averell Harriman, board chairman, that they had found America's heretofore undiscovered winter wonderland for him in a valley a mile from the old mining town of Ketchum, Idaho.

Before spring was over, Mr. Harriman and his directors had decided to invest more than $1,000,000 in making Sun Valley—with which name they christened their new child—the nation's No. 1 winter spot during the season of 1936-37.

On June 3, 1936, ground was broken for the lodge building, and on December 21, 1936, the combined forces of the J. V. McNeil Company, general contractors, and the engineering department of Union Pacific turned it over to the operators. During Christmas week, scores of people from all over the nation came to Sun Valley for the grand opening of America's first big-time winter paradise.

Rivaling St. Moritz and other first-line continental winter resorts in swank and skiing facilities, Sun Valley has more attractions than mountains, long ski-runs and fine snow. The whole layout presents a series of delightfully perplexing

*Manager, News Bureau, Union Pacific Railroad Company.

contradictions that will probably never fail to intrigue—skiing comfortably in shirt-sleeves or stripped to the waist, swimming out-of-doors in zero weather, and a concrete lodge that looks like a massive timber manor house.

The job of building Sun Valley Lodge was done in record time. Out there, where even labor had to be imported, the builders worked on a schedule that was faster than might be expected in metropolitan areas.

The lodge is built of concrete. No fear of fire. No danger of decay and deterioration during the months when there will be no snow. It cost a million dollars, but it was built to last and to call for but a minimum of maintenance expense.

In structural design and construction, Sun Valley Lodge is quite like any other large reinforced concrete building. In architectural design and in concrete finish it is widely different. Because the mountains and hills are constantly covered throughout the winter with gleaming white snow, it was decided that the lodge should have a sharply contrasting color, a relief from the white. Consequently, instead of natural-colored or white concrete finish, the exterior walls are stained dark, and the surface detail is consistent with this color effect.

When winter came to Sun Valley.

The walls were cast against wide, rough form boards. The joint lines between form boards in the lower courses are deeply rusticated horizontally and in upper courses diagonally. Since the grain marks of the boards were left in the concrete as it came from the forms, the dark stain gives the impression of walls of wide, natural timber.

Native stone was used effectively in some places, particularly in veneering the concrete framework of the terraces. On the balconies, timber rails were set into concrete posts; but from even a short distance away the entire building looks like wood.

Every floor, from basement to attic, is reinforced concrete. Inside, the floors are carpeted or covered with rubber matting. On the sun porches they are chemically stained.

All piping, heating and plumbing and conduits, are concealed, either in the dead air spaces between the exterior concrete wall and the gypsum tile inner wall, or in partitions. The air space forms effective insulation and aids greatly in reducing sound conduction.

In many of the rooms the fireplaces are concrete, cast in place with the walls. The huge fireplace in the game room is fronted by a concrete hearth raised 1 ft. above the level of the floor. About 12 x 4 ft. in size, this hearth affords a splendid place for skiers to toast themselves after being out.

In plan the lodge is a double-Y, making it possible to give outside exposure to every room in the house. Rooms on the south side have the further advantage of sun balconies and decks, the latter accessible to eight rooms, four each on opposite wings. These balconies are set back on the second and third floor levels and are about 16 ft. square.

The erection of Sun Valley Lodge was a big job. Naturally, there was no equipment available near the location. Most of it was brought from the west coast. Very little skilled labor could be obtained nearby, but part of that problem was solved by the two sons of J. V. McNeil of the general contracting firm. They gathered a crew of huskies from the University of Southern California, Stanford and U.C.L.A., who made the concrete mixers hum. Viewing the job as more of a lark than work, and as a splendid opportunity to train for the coming football season, the collegians set a fast pace for all workers on the job. This was partially responsible for the rapidity with which the job was concluded.

Sand and stone had to be hauled in for the project, and upwards of a half-million dollars was invested in water and sewerage systems and installation of apparatus to handle power furnished by established sources.

One unique feature of Sun Valley is its 60-ft. circular concrete outdoor swimming pool. Believe it or not, one can swim there without any roof and only the protection of low side-walls, when the thermometer indicates "zero." The reason is that the sheltered valley suffers no breezes and the water comes from hot springs. An enclosed approach runs directly from the lodge to the pool which is sheltered

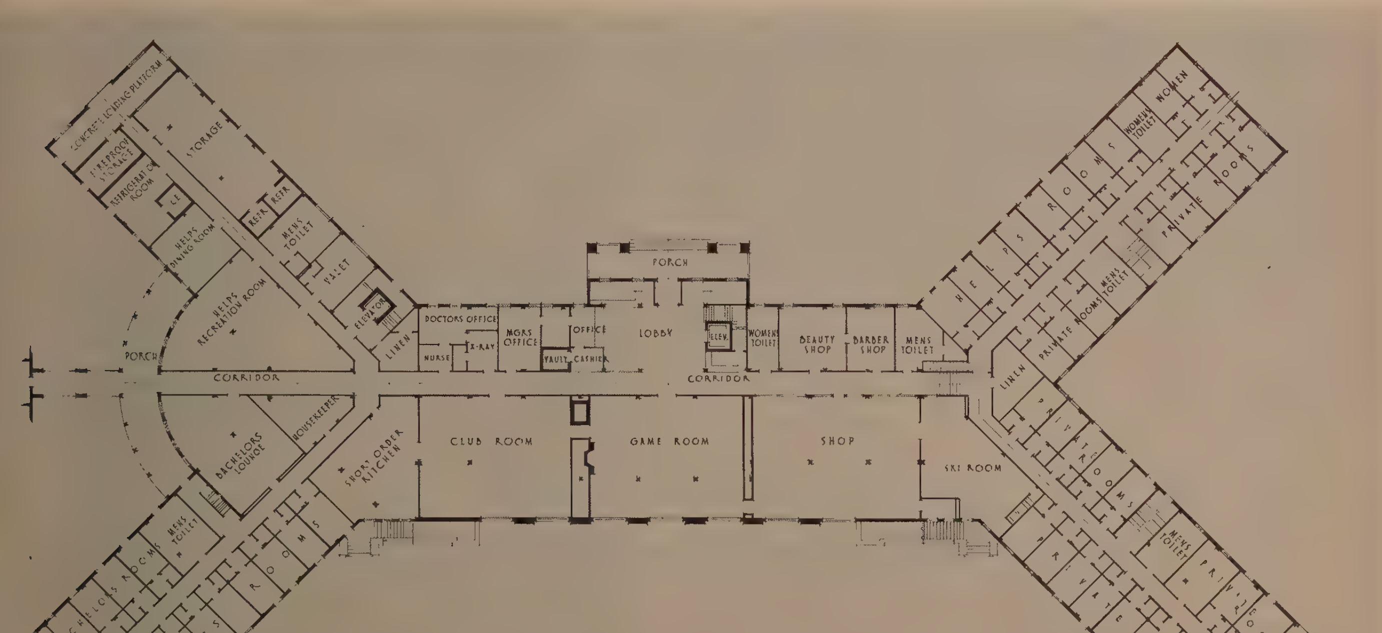
Guests can mush, ski, slide and enjoy the luxurious accommodations of Sun Valley Lodge which include outdoor swimming in the concrete pool where hot spring-fed water may be seen steaming at the left of this picture.

at the sides by glass panels set in a series of concrete posts.

Chief attraction of Sun Valley, of course, is skiing. The "powder snow" that makes the best skiing abounds there throughout the winter. A brilliant sun shines all day, and with no wind to toss cold about, the skier can be stripped to the waist and still be comfortable. The long slopes of the hills are practically treeless, permitting "runs" three miles long. To eliminate waste of time in climbing to the tops of runs, ski lifts have been installed—endless cables which pull the skier to the summits without effort. One lift has back rests, the other actual chairs.

The lodge, which makes it possible for large numbers to take advantage of this winter playground, is naturally the hub of activity. It has accommodations for 250 guests, a sports store, ball room, game rooms and entertainment facilities. Although far from any metropolitan area, it is protected by its firesafe construction from hazards which plague less substantially built resort hotels.

Original sketches for Sun Valley Lodge were prepared by G. Stanley Underwood, Los Angeles and Washington, D.C., architect. Design details throughout the planning and construction were under the supervision of W. T. Wellman, architect for Union Pacific Railroad Company. Howard C. Mann, recently named vice-president in charge of operations for the entire road, and G. H. Trout, bridge engineer, were others closely concerned with the project.



FIRST FLOOR OR GROUND FLOOR PLAN

Memorial Auditorium, Fresno, is one of two architectural concrete civic buildings recently designed by the Allied Architects of Fresno, Calif. Contractors were Trewhitt, Shields and Fisher and J. W. Ochs.

Fresno Architec

By J. E. Jellick*

FRESNO, Calif., is not a big city; but its public buildings, based on recent construction activities, will one day match in splendor those of many a larger city. Two most interesting structures, erected during the past year, were designed by a group of local architects associated as the Allied Architects of Fresno. The buildings are a Hall of Records and a Memorial Auditorium.

According to their functions, each is quite different in exterior design. The Hall of Records is an office building with generous fenestration, three stories high, laid out on a more or less conventional plan. The Auditorium is a monumental structure, a classical modification of modern forms in which the masses are balanced and decoration is kept to a minimum. A casual glance might not reveal that the same group of designers had a hand in the planning of both structures. Yet the features that unify the buildings and tie them into a county municipal group—similar details on columns, copings and dentils—also suggest a common source of their architecture.

The Auditorium, the consummation of a long desire of the citizens of Fresno to replace their old, unsightly public auditorium with a beautiful, appropriate structure, was a half-million dollar project. Started with a $400,000 bond issue and Federal aid through PWA, the building occupies a large part of a city block located within four squares of the center of the business district. With a floor area of 160 x 235 ft. over-all, the main auditorium occupies the central portion of the structure and is 102 x 144 ft. in plan. Seating for 3500 is accomplished by the use of 2,000 movable chairs on the main floor and 1500 opera chairs in the balcony. The main floor may thus be cleared for dancing or exhibition purposes when the auditorium is used as a convention hall.

In construction, the auditorium is a skeleton steel frame enclosed by concrete bearing walls. Floors and the stage loft, including the proscenium wall, are reinforced concrete. In compliance with California laws, the structure was designed for a seismic factor of 3 per cent.

*District Engineer, Portland Cement Association, San Francisco.

Detail on the auditorium was limited to simple molded ornamentation.

[redacted]

sign Civic G[redacted]

Particular consideration was given to the [redacted] and finishing of the exterior concrete walls. [redacted] mix of $1:2\frac{1}{2}:3\frac{1}{2}$ with 5 gal. added water [redacted] concrete of 3-in. slump was placed in 8-in. [redacted] well. The result is dense concrete walls [redacted] and well defined. After the 1 x 6 T-[redacted] stripped, the walls were given a dash coat [redacted] spray paint coat. Form marks which lend [redacted] plain surfaces are quite apparent under the finish treatment.

The exterior ornamentation, which relieves the austerity of the rectangular outline of the building, comprises both cast-in-place and precast elements—the latter strongly anchored to the walls. Most of the cast-in-place details were formed in plaster waste molds.

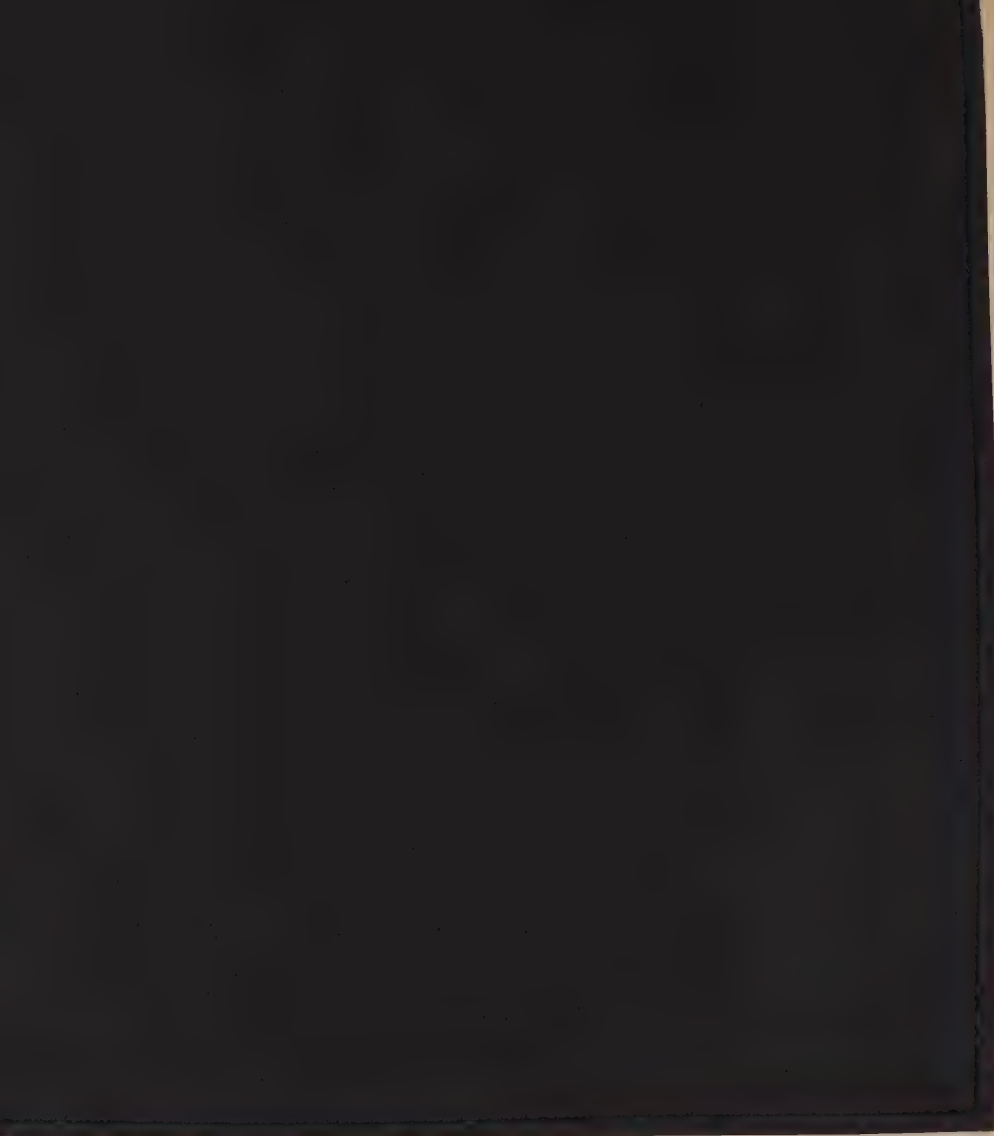
[redacted] spandrels are aluminum in modern design patterns.

Throughout the building, which contains office suites for the county treasurer, auditor, tax collector, assessor and recorder, the concrete sub-floors are finished in different materials. The corridor floors and terrazzo in which white portland cement was used to enhance the brilliance of color; in offices linoleum is used; and in waiting rooms and halls the floors are covered with rubber tile.

The general contract, awarded to William Spivock, amounted to $253,541. Total cost of the building including equipment and installations was $361,352.

Now completed and occupied, the Auditorium and Hall of Records are widely regarded for their splendid appearance and their distinctive architecture. The designers, the Allied Architects of Fresno, which include W. D. Coates, Fred L. Swartz, H. Raphael Lake, Charles H. Franklin, E. J. Kump and E. W. Paterson, are being praised for their excellent work which, it is agreed, has set a new standard for monumental construction in the San Joaquin Valley.

The coping band was cast in plaster molds, other detail in milled forms.



A modern structure with architectural features strongly reminiscent of the Gothic is St. James Church, Vancouver, B. C. It is architectural concrete, finished with brush coat stucco. Adrian Gilbert Scott, London, was the architect with G. L. Thornton Sharp and C. J. Thompson of Vancouver, associates. Pacific Engineers, Limited, was the contractor.

Modern Church in Vancouver

By G. L. Thornton Sharp, A. R. I. B. A.

IN designing a church for these times, the architect is confronted with problems which generally do not arise in the planning of other types of structures. He is tempted, on the one hand, to use modern materials in their most characteristic forms, designing sweeping masses bound in simple lines not only because they reflect the moving spirit of the time but because of the economy of their execution—which is important. On the other, he is restrained by ecclesiastic tradition, which has changed imperceptibly over hundreds of years, to design in familiar forms. He knows full well that traditional religious architecture is old and honorable and beautiful and that certain distinctive forms and details, like the faith, are not to be set aside easily. The only acceptable alternative is a genial compromise, clothing the spirit of all time in the flesh of today.

St. James Church in Vancouver, B.C., is a modern edifice. Were one to look closely at the fundamental form beneath its dentils, buttresses, gargoyles, steep roofs and deeply recessed lancet windows so characteristic of the Gothic, one would find a simple grouping of masses depending upon shadow-play for definition of its lines. The structure employs concrete, a most modern construction material, for not only its massive form but for its most delicate detail.

Although not a large church, seating but five or six hundred, considerable study was required in planning to fit it to the vacant portion of a limited city lot already half-filled by a parish house and with a clergy house occupying one corner. The structure is built on a cruciform plan, lying east and west with short transepts north and south and with an octagonal tower rising over the intersection. This tower is topped with a steep-pitched, green-slate-covered roof with copper louvres in the top section running completely around it. A gilded wrought iron cross rises at the apex. Inside is a flat ceiling 50 ft. above the floor, with a belfry above designed to contain a peal of bells. These bells, when installed, will weigh from 10 to 12 tons, and will be carried on four concrete trusses of queen post form intersecting each other at the posts. The trusses are $14\frac{1}{2}$ ft.

top to bottom with a span of 46 ft.

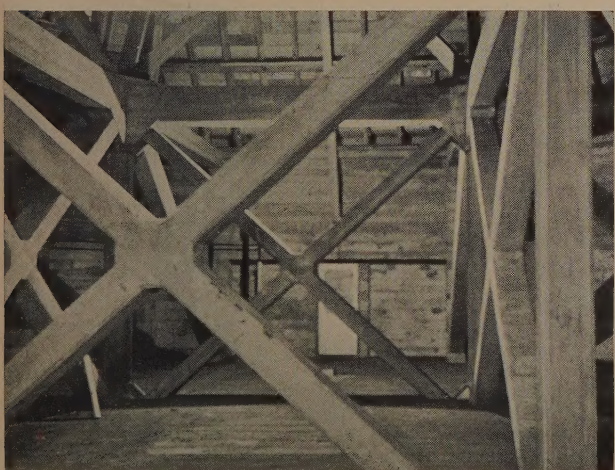
The main entrance is one story high and is located on an angle with a circular baptistry on one side between it and the south transept. A similar space on the other side of the entrance is occupied by a concrete stair with wrought iron handrail leading to the gallery over the west nave.

Behind the sanctuary at the east end is an ambulatory connecting with the parish house and the clergy house. This is reached from the church by north and south choir aisles, and beyond it, separated by a glazed screen, is the Lady Chapel which is octagonal in shape. Above the screen and ambulatory is a gallery to the chapel which opens into the main church.

On the east wall of the south transept is a small altar and in the north transept an organ loft is reached by a circular turret stair. The organ loft, owing to the restriction of the site, is cantilevered over the hall roof with the floor following the slope of the roof.

A series of arches separates the different parts of the church; the nave, north and south transepts and sanctuary have plaster arched ceilings; the central portion of the nave under the tower and all other portions have flat ceilings made of cedar, those of the tower and chapel being coffered. The walls are paneled with cedar about 6 ft. high, the balance of the walls and ceiling being acoustic plaster with the exception of the two ends, which have ordinary plaster matching the acoustic surface in texture and color.

The exterior is simple and shows clearly the construction and plan of the church. The walls of the central tower are 3 ft. thick, comprising an 8-in. and a 5-in. concrete wall separated by a 1-ft. 11-in. air space. The thickness of this wall permits deep recessing of all openings, thereby emphasizing the mass and the Gothic feeling of the decorative detail. The outer wall, cast against rather wide form boards, retains the texture of the forming material through a brush dash coat of stucco. In erecting the double wall forms,



Reinforced concrete trusses of queen post form will support a 12-ton chime of bells in the tower.

Most of the interior wall surfaces of St. James Church are finished with acoustical plaster.

concrete spreaders were used. The spreaders were cast with a hole through the center for the tie rods which were pulled out of the wall as soon as the concrete had hardened sufficiently to permit loosening the forms without damage.

All decorative features, such as the tracery in the chapel, the scupper gargoyles and the reticulated parapet walls, were placed monolithically with the main structure. These details, although somewhat more complicated than the rest of the formed surfaces, were very easily molded by using standard sizes of milled wood set against the form faces. The sharpness of this detail attests the quality and workability of the concrete used, as well as accurate form construction.

The basement is used as a large assembly hall with kitchen, cloak rooms and a heating chamber occupying some of the space. Heating throughout the building is accomplished by means of a panel system of coils laid in 3-in. concrete on top of the floor slab. Thus far it is the only example of this method of heating on this continent, with the exception of the British Embassy in Washington. It has proved very satisfactory so far in the climate of this Province which nearly resembles that of Great Britain where panel heating is quite common.

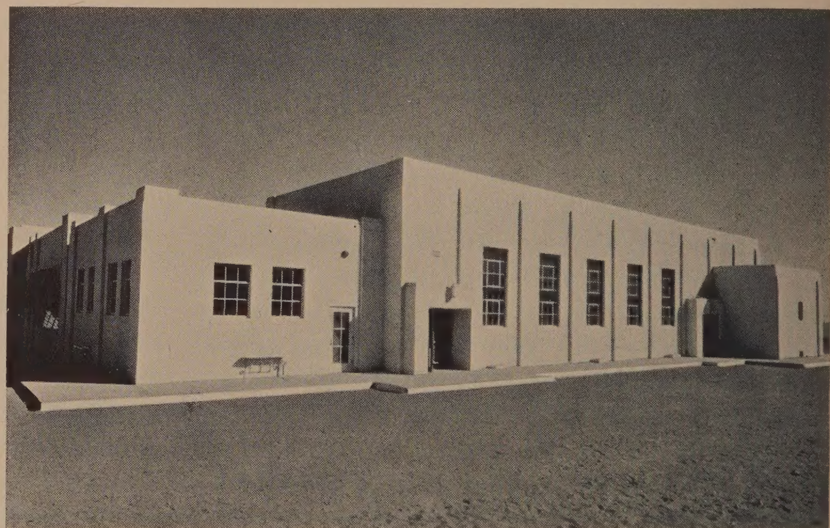
The concrete floor is marked off in 2-ft. squares which are alternately colored with green and brown dychrome stain, and waxed to a fine polish.

Adrian Gilbert Scott, F. R. I. B. A., of London, was the architect with the writer and C. J. Thompson, A. R. I. B. A., as associates in charge of work on location. F. W. Urry was structural engineer.

Contractor for the project was Pacific Engineers, Limited, with A. J. Armstrong as general superintendent and T. K. Loach as resident engineer.

In rebuilding Conley School at Taft, Calif., to meet state structural requirements, reinforced concrete columns were inserted in the walls and the entire exterior was given an overcoating of white portland cement stucco to match a reinforced concrete addition at the rear. Charles H. Biggar was architect for the project and Carl Ingalls, Inc., the contractor.

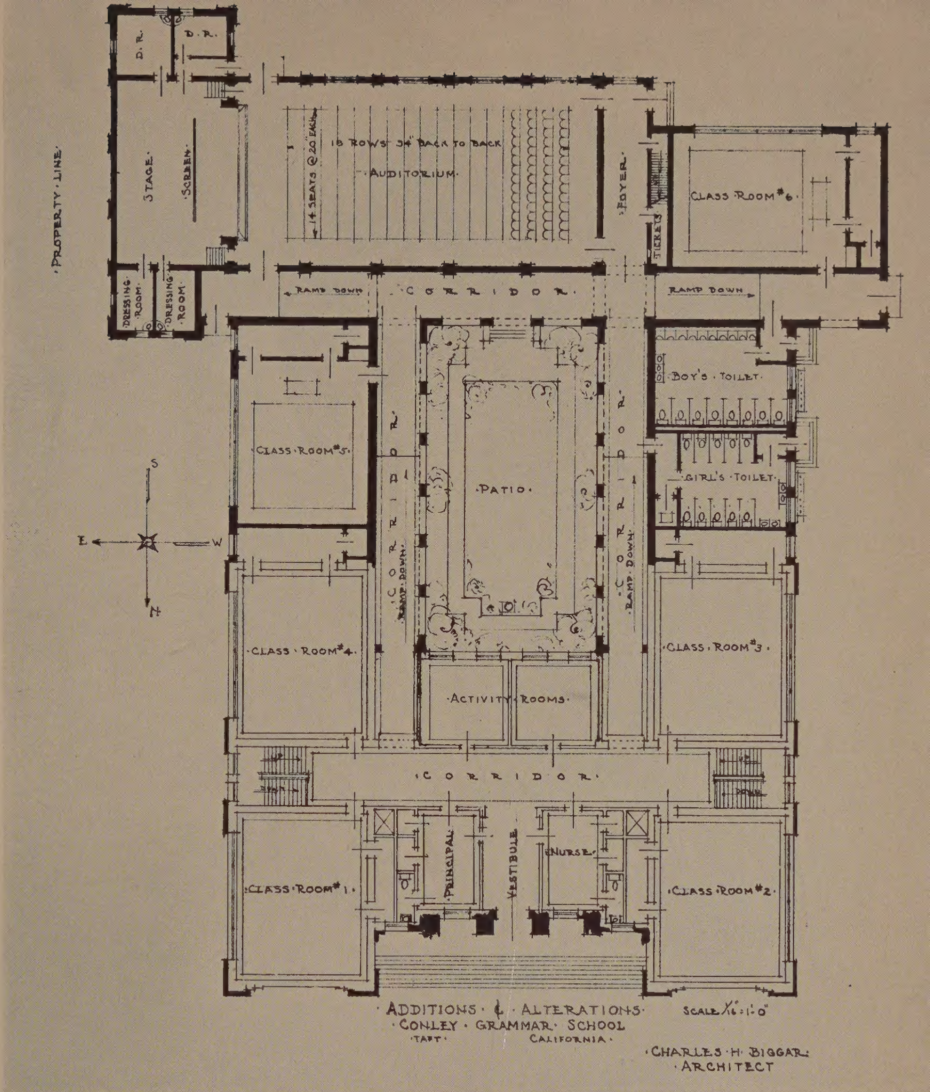
Rebuilding an Old School



By Charles H. Biggar, A. I. A.

MINIMUM safety requirements for school construction, made into law following the southern California earthquake of 1933, have caused wide changes in the appearance of most of the schools in the state. Not only were buildings partially demolished or damaged by the tremors declared unsafe, but many other structures in areas unaffected by the disturbance, but definitely vulnerable in case such a disaster should strike, were ordered rebuilt or strengthened to comply with the earthquake laws. In some cases this meant the razing and rebuilding of entire structures. In others, such drastic redesign of structural members was necessary that it was found quite economical at the same time to modernize the architecture.

Thus it is that scores of California schools are entirely new in structure and architecture, while others, in which a large portion of the old buildings were salvaged, have



strengthened walls and entirely new faces.

The elementary classes of the Conley School district of Taft, Calif., occupied a two-story brick building which was declared unsafe because of earthquake and fire hazard. It was necessary that new facilities be provided, but since funds were limited, it was decided that as much of the existing building should be salvaged as possible.

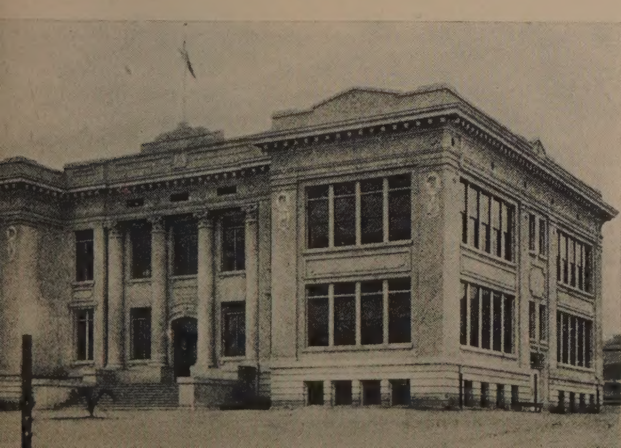
Plans for the new structure were started in January, 1934. The building contract was awarded on June 29 of that year to Carl Ingalls, Inc., at $56,628. With a PWA grant of $16,500, work proceeded.

The remodeling program called for removal of the second floor, which was an auditorium, the strengthening of the brick walls and modernizing the remaining one-story structure so that its architecture would be consistent with a new one-story auditorium and class room building to be erected on adjoining space.

In strengthening the old building, the brick work was removed down to a line along the top of the windows. Concrete columns 8 in. thick and 6 ft. wide were placed at corners and at intervals along the sides of the brick walls. These columns were reinforced horizontally with $\frac{3}{8}$-in. rods on 12-in. centers, and vertically with $\frac{5}{8}$-in. rods. The new columns were anchored to the brick with $\frac{3}{8}$-in. round bars, flattened on the end to $\frac{5}{8}$-in. and grouted into 1-in. holes drilled into the brick walls.

A reinforced concrete bond beam was placed around the entire wall and carried above the roof line to form a parapet.

ld Taft School before modernizing with concrete and stucco.



Since the new auditorium and class room addition was built of reinforced concrete used in a modest design of fluted pilasters and plain spandrel walls, it was considered highly important that the old structure conform in appearance. This was achieved by placing an overcoating of white portland cement stucco over the old brick walls between the columns and below the bond beams. The stucco surfaces were so treated that they conform in color, texture and detail with the concrete of the new portion of the building. Since both structures are tied together with anchor rods, and their exterior finishes are so similar, the entire layout now stands out as a unit—in effect a completely new school building. It was only through the use of such readily combined and economical materials as reinforced concrete and stucco that architectural unity was possible.